Exhibit 2

Statewide Ridership Analysis Report

Statewide Analysis Model –Version 2.5 (SAM-V2.5)

December 2013

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Version History

Release Date	Version Number	Description
December 12, 2013	1.0	Original Submission
December 13, 2013	1.1	Revised draft to include requested mode share data
December 23, 2013	1.2	Revised draft submittal to address comments received

Executive Summary

The Statewide Ridership Analysis was completed to provide a high level evaluation of forecasted ridership and cost effectiveness for various corridors in the state in order to determine which corridors may warrant further analysis, should funding become available, and what level(s) of service may be supported by the different corridors. The analysis included stakeholder coordination throughout the state, analysis of transit connectivity in urban areas and intercity travel demand as part of the development of the ridership model, the Statewide Analysis Model Version 2.5 (SAM-V2.5). The SAM-V2.5 provides the framework to estimate intercity passenger rail ridership for various corridors throughout Texas as well as to certain cities located in neighboring states.

The development of the SAM-V2.5 included updating the existing TxDOT Statewide Analysis Model (SAM V2), which is used by the State to analyze and forecast passenger and freight travel throughout the state, in order to better address the passenger rail travel mode and to expand the model, which was previously limited to Texas boundaries, to also include the immediate surrounding states of Louisiana, Arkansas, Oklahoma, and New Mexico.

Potential intercity passenger rail city pairs evaluated in the Statewide Ridership Analysis were determined based on an evaluation of population, corridor distance, and existing travel demand. The city pairs were evaluated for three different levels of service, based on the definitions contained in the National High Speed Rail Strategic Plan, summarized below.

- Core Express Service
  - Maximum speeds between 125 and 250 mph
  - Frequent, express service between major population centers 200 to 600 miles apart with few, if any, intermediate stops
- Regional Service
  - Maximum speeds between 90 and 125 mph
  - Relatively frequent service between major and moderate population centers 100 to 500 miles apart with some intermediate stops
- Emerging/ Feeder
  - Maximum speeds up to 90 mph
  - Developing corridors of 100 to 500 miles, with strong potential for future regional or core express service
  - Located primarily on shared track with existing rail lines

The various city pairs and associated levels of service evaluated in this analysis are shown in Figure 1.

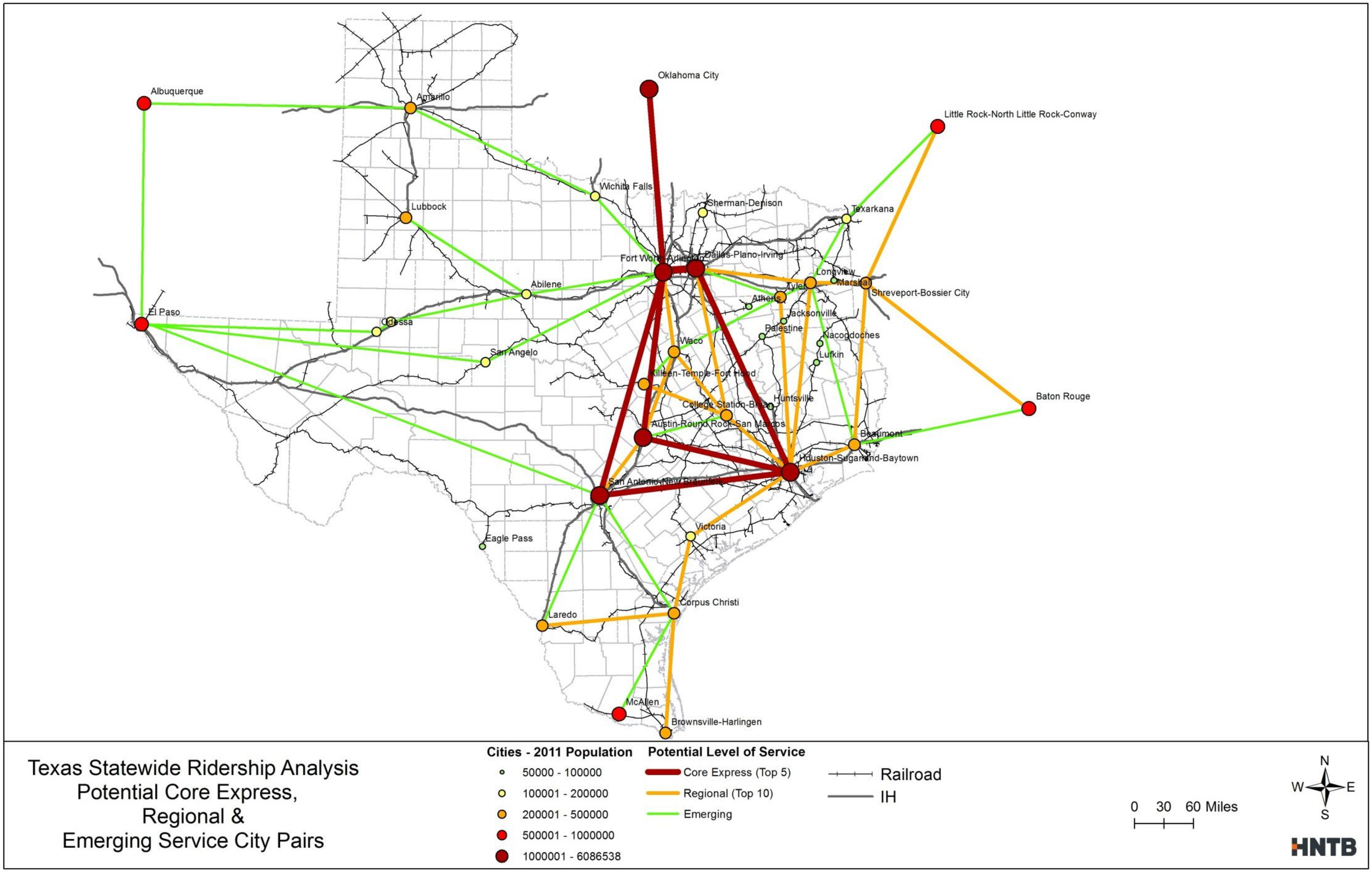

Figure 1: Potential Corridors for Core Express, Regional, and Emerging Service

The model was then used as part of a cost effectiveness analysis of the potential passenger rail corridors to obtain travel demand model output values, revenue from fares and time savings (user benefit hours) associated with the potential intercity passenger rail service. The cost effectiveness of the potential passenger rail corridors was evaluated based on the cost recovery ratio (annual revenue from fares divided by annual operating and maintenance costs) and the cost per hour of user benefit (time savings).

Lastly, a probability analysis was performed for the estimates of capital and annual operating and maintenance costs, as well as for the forecasted ridership for the corridors evaluated in the model. The results of the probability analysis allowed the cost estimates and ridership forecasts to be reported in ranges, rather than single point estimates. The probability analysis addressed the uncertainties in estimated costs and forecasted ridership that are inherent to a statewide high-level study of this nature where there are still many unknowns that would need to be further evaluated and clarified in more in-depth corridor level studies.

The analysis was not intended to provide a detailed ridership analysis of any individual corridor, since many assumptions were applied to all of the corridors statewide and would need to be modified to more accurately reflect the characteristics of any particular corridor. However, care was taken to account for the variability and uncertainty in the forecasted ridership results produced as reported in ranges shown in Table 1.

Table 1 shows the summary ridership results for the corridors evaluated in the Statewide Ridership Analysis that were determined to meet minimum cost effectiveness requirements for each service level as defined by the cost recovery ratio (annual revenue from fares divided by annual operating and maintenance expenses) thresholds listed below:

- Core Express Service – 100%
- Regional Service – 75%
- Emerging Service – 50%

Table 1: Forecasted 2035 Intercity Passenger Rail Ridership Summary Results[1,2]

Origin	Destination	Upfront Capital Cost	Annual O&M Cost	2035 Annual Ridership (P70)
Core Express Service				
Austin	Houston	$11B	$125M	1.1M – 4.1M
Houston	San Antonio	$13.3B	$152M	0.8M – 3.1M
Dallas	Houston	$16.8B	$266M	1.5M – 5.7M
Dallas	Austin	$15.2B	$273M	0.8M – 2.9M
Fort Worth	Houston	$19B	$301M	1.5M – 5.8M
Dallas	San Antonio	$20.7B	$351M	1.7M – 6.5M
Dallas	Oklahoma City	$15.5B	$177M	0.5M – 1.8M
DFW/ Airport	Houston	$17.4B	$276M	1.5M – 5.4M
Regional Service				
Waco	Houston	$6.3B	$91M	1.1M – 3.7M
Fort Worth	Bryan-College Station	$6.8B	$97M	0.7M – 2.3M
Houston	Killeen	$6.6B	$94M	0.7M – 2.3M
Emerging Service				
Waco	Houston	$3.1B	$19M	0.3M – 1.5M
Tyler	Houston	$4.6B	$27M	0.3M – 1.5M
Killeen	Houston	$3.5B	$20M	0.2M – 0.9M
Fort Worth	Bryan-College Station	$3.4B	$20M	90K – 0.5M

[1] Dallas/ Fort Worth region to Houston and Dallas to San Antonio corridor results shown in Table 36 are based on the optimized model runs performed with decreased fares to account for competitive air fares in those corridors rather than federal mileage rate fares utilized for other corridors.

[2] Forecasted passenger rail ridership reported does not include induced ridership.

The ridership forecasts shown in Table 1 are based on the corridors being implemented singularly, and do not account for the corridors acting as part of a system. A Core System was evaluated by combining high-performing individual corridors based on professional judgment and the rankings from the travel market and cost effectiveness analyses. The Core System is shown in Figure 2 and the resulting performance of the Core System is summarized in Table 2.

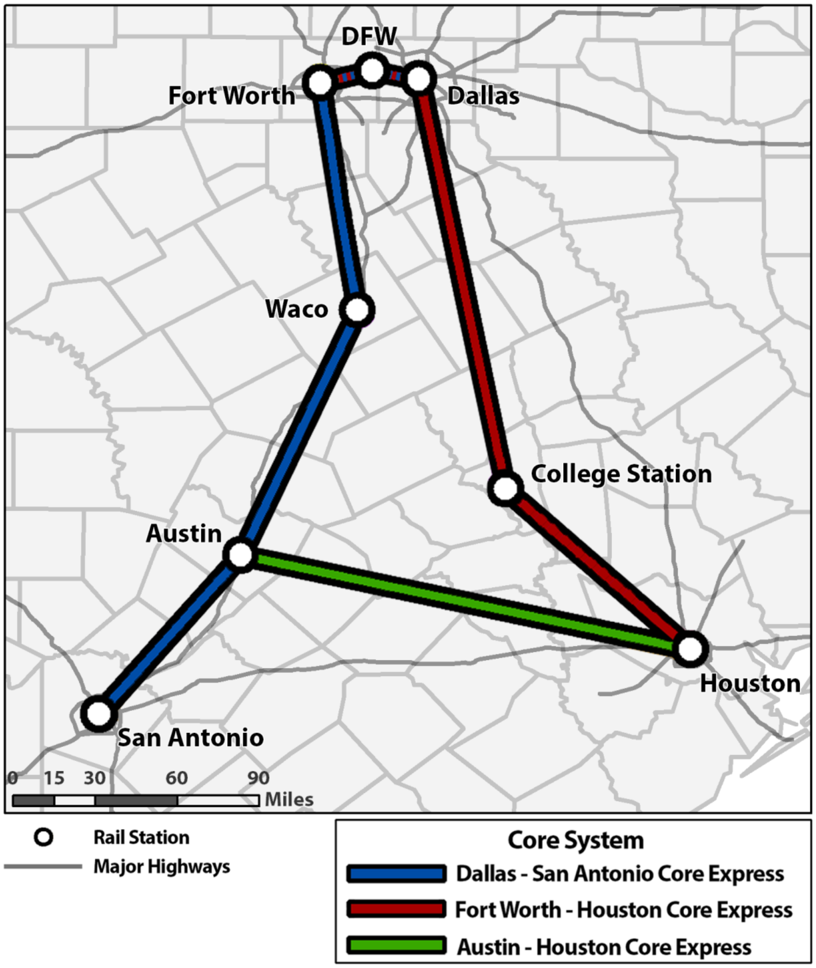

Figure 2: Core System Route Concept

Table 2: Core System Performance Measures[3]

Performance Measure	Upfront Capital Cost	2035 Annual Ridership
System Total	**$48.5**	**4.3M – 16.4M**
Total Revenue: Dallas – San Antonio Core Express	$20.7B	1.7M – 6.5M
Total Revenue: Fort Worth – Houston Core Express	$16.8B	1.5M – 5.8M
Total Revenue: Austin – Houston Core Express	$11B	1.1M – 4.1M

After the Core System was run, additional corridors were added iteratively to the Core System to create new candidate systems. When run together in various combinations as part of a system, the results generally showed that while each additional corridor had its own independent utility, the addition of new corridors to the system caused the cost effectiveness of the system to decrease due to higher system costs and somewhat redundant services. For example, the decrease in forecasted ridership and revenue along the Austin to Houston corridor resulting from adding the San Antonio to Houston corridor and the overall significant reduction in the system cost recovery ratio implies that the two core express corridors are somewhat redundant. Similar results were found for the Waco to Houston and the Killeen to Houston corridors.

Additionally, there were negligible transfers between the Dallas/ Fort Worth to Houston and the Dallas/ Fort Worth to San Antonio corridors. This is due to the nature of the geography for those two corridors, which essentially form the sides of a triangle. For example, the cost and trip time required to get between Houston and Waco would not be competitive via transfer between the two core express routes (going through Dallas/ Fort Worth) as compared to either driving or flying directly between the two cities. As a result, there was little system effect to the individual corridor ridership of including these two corridors together in a system. However, the ridership was increased by combining the Austin to Houston and Dallas/ Fort Worth to San Antonio corridors in a system, as there were transfers between those two routes. In conclusion, a “triangle system” causes little increase to corridor ridership forecasts, while a “T” system would experience greater transfers and resulting increases to individual corridor ridership forecasts.

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[3] Dallas/ Fort Worth region to Houston and Dallas to San Antonio corridor results shown in Table 39 are based on the optimized model runs performed with decreased fares to account for competitive air fares in those corridors rather than federal mileage rate fares utilized for other corridors.

1.0 Introduction and Purpose

The Statewide Ridership Analysis was completed in order to develop a Statewide Passenger Rail Ridership Model that provides the framework to estimate intercity passenger rail ridership for various corridors throughout Texas as well as to certain cities located in the adjacent states of Louisiana, Arkansas, Oklahoma, and New Mexico. The analysis included stakeholder coordination throughout the state, analysis of transit connectivity in urban areas and intercity travel demand as part of the development of the ridership model, the Statewide Analysis Model Version 2.5 (SAM-V2.5).

The statewide model is intended to provide a high level evaluation of ridership and cost effectiveness for various corridors in order to determine which corridors may warrant further analysis, should funding become available, and what level(s) of service may be supported by the different corridors. The model also provides the framework that can be efficiently modified for use in a corridor level ridership model, rather than having to create a new model from scratch for every individual corridor. Assumptions for inputs impacting ridership (e.g., fare, travel speeds, access and egress times at airports and rail stations, etc.) were developed as described in this report and used consistently for all of the corridors evaluated. Corridor-specific characteristics that may impact the inputs utilized in the ridership model, and therefore the forecasted ridership, would need to be evaluated in individual corridor level studies. Additionally, the model does not include corridor alignments for the passenger rail routes, but rather consists of a nodal analysis of ridership based on various levels of service (i.e., speed, frequency, etc.) for intercity passenger rail between specified cities.

The development of the SAM-V2.5 included updating the existing TxDOT Statewide Analysis Model (SAM V2), which is used by the State to analyze and forecast passenger and freight travel throughout the state, in order to better address the passenger rail travel mode and to expand the model, which was previously limited to Texas boundaries, to also include the immediate surrounding states of Louisiana, Arkansas, Oklahoma, and New Mexico.

The model was then used as part of a cost effectiveness analysis of the potential passenger rail corridors to obtain travel demand model output values, revenue from fares and time savings (user benefit hours) associated with the potential intercity passenger rail service. The cost effectiveness of the potential passenger rail corridors was evaluated based on the cost recovery ratio (annual revenue from fares divided by annual operating and maintenance costs) and the cost per hour of user benefit (time savings).

Lastly, a probability analysis was performed for the estimates of capital and annual operating and maintenance costs, as well as for the forecasted ridership for the corridors evaluated in the model. The results of the probability analysis allowed the cost estimates and ridership forecasts to be reported in ranges, rather than single point estimates. The probability analysis addressed the uncertainties in estimated costs and forecasted ridership that are inherent to a statewide high-level study of this nature where there are still many unknowns that would need to be further evaluated and clarified in more in-depth corridor level studies.

2.0 Overview of Model Development

The SAM-V2.5 is a traditional four-step model with trip generation, trip distribution, mode choice, and trip assignment. The SAM-V2.5 was developed, calibrated, and validated for a base year of 2010 and forecast year of 2035. Trip generation, trip distribution, and mode choice are separate models for passenger and freight travel. The SAM-V2.5 was designed to assign the following modes of travel to their respective network layers:

- Highway (passenger and truck),
- Passenger rail, and
- Freight rail.

For highway assignment, the passenger and freight model outputs are combined to allow for a joint assignment of passenger vehicles and trucks to the highway network. This is relevant for passenger traffic, as the freight volumes impact traffic flow. The resulting congestion affects passenger volumes on the highway, which can ultimately impact the attractiveness of passenger rail as a mode of travel.

Several modifications were made to the SAM during model development to update the model for use in the Statewide Ridership Analysis. For the SAM-V2.5, the main efforts were focused on the refinement of the mode choice model developed in the SAM-V2. Based on a review of other inter-regional models and special needs for the policy analysis of HSR, one of the refinements was the addition of egress modes in the transit skim process, and the mode choice model structure. To further analyze the competition among HSR and air travel, reliability measures were added to the utility function for rail and air modes. The impact of frequency of service and convenience of departure time on mode choice were also investigated. In addition, different scenarios for out-of-vehicle travel time constraints were explored, including reasonable wait time and realistic out-of-vehicle travel time were explored. In comparison to the SAM-V2, version 2.5 includes the following enhancements:

- Expanded five state study area
- Updated Passenger mode choice

- Updated 2010 demographics

The following sections summarize the development, validation, and testing of the SAM- V2.5. Additional details about the model development can be found in the Model Development Report.

Trip Generation

Trip generation, which is the first of the four primary steps in the travel demand modeling process, produces a set of trip productions (origins) and trip attractions (destinations) for each traffic analysis zone (TAZ) by trip purpose.

The production rates for the SAM-V2.5 were derived using *2009 National Household Travel Survey* (NHTS) data, more specifically, the 20,000 sample add-on surveys sponsored by TxDOT. Trip rates are for motorized person trips. Passenger trip productions are stratified by:

- Four household size categories,
- Four income categories, and
- Eight area type categories.

Both the household size and income stratifications were determined using *2000 Census Transportation Planning Package* (CTPP) data.

Trip attractions were estimated from workplace surveys conducted in four urban areas in the state and the *2009 NHTS*. Attraction rates were estimated by area type, employment type, income group, and trip purpose. The stratification by income group was included to allow income segments to be maintained throughout the model stream for use in the traffic assignment step. This stratification allows for more accurate analysis of toll facilities and more detailed interpretation of mode choice utilities.

Trip Distribution

Trip distribution, which is the second step in the traditional four-step model, takes the production and attraction trip ends developed during trip generation and connects them in origin–destination pairs based on the trip length frequency curves for each trip purpose. A traditional gravity model with calibrated friction factors by trip purpose is utilized for trip distribution in SAM-V2.5. Trip lengths are expressed in minutes or miles and are derived from the *NHTS*. Separate distribution models are run for the income segments within each trip purpose.

Mode Choice

Mode choice, which is the third step in the travel demand modeling process, uses production and attraction person trip tables produced by the trip distribution program, combined with traveler characteristics, origin and destination data from the TAZ layer, and zone-to-zone travel impedances to allocate the trips to the available modes of travel. The SAM-V2.5 passenger mode choice model is structured as a nested logit model. The mode choice models are structured in a manner similar to many urban models in which peak travel times are used for work-related trip purposes and mid-day travel times are used for non-work related trip purposes. This structure allows one mode choice model to be run for each trip purpose. The time of day step takes place after mode choice, thus avoiding the running of four mode choice models for each trip purpose. Trips can be forecast for auto drivers, auto passengers, intercity rail passengers, high-speed rail passengers, and air passengers.

Freight Models

The units of measurement for the productions and attractions at the origin and destination of freight trips are expressed in annual tonnage for 15 commodity types. An incremental logit choice model produces flow tables for the 15 distinct commodity types considered in SAM-V2.5. Modes include truck, carload rail, and intermodal rail. The baseline for applying the increments is a Texas-focused TRANSEARCH database purchased by TxDOT.

While the freight rail and passenger rail modes are separate within the SAM-V2.5 architecture, the freight models can still have an impact on passenger rail. For highway assignment, the passenger and freight model outputs are combined to allow for a joint assignment of passenger vehicles and trucks. The freight vehicles (trucks) and passenger vehicles combine to affect traffic flow and increase travel delay due to congestion on the highway facilities, which can ultimately impact the passenger rail volumes.

Assignment

Trip assignment, the final step in the travel demand process, assigns trips to the highway network. In SAM-V2.5, the passenger and freight highway trips are combined and assigned using a multi-class highway assignment procedure. The model is designed to perform at the daily (i.e., 24-hour) level and also has the flexibility to examine four distinct time periods: AM Peak, Mid-Day, PM Peak, and overnight. Toll analysis is handled with a generalized cost function during traffic assignment. Daily flows of truck tonnages are converted to freight trucks for assignment purposes using payload factors for each commodity group.

The SAM-V2.5 is designed to apply multiple volume delay functions (VDFs) varied by functional classification, and to account for both link and intersection delay. This approach allows the attributes of specific types of roadways to impact how quickly delay builds up, and for the assignment to be influenced by both link delay, and delay experienced at intersections regulated by traffic control devices (i.e., signals and stop signs). A set of VDF parameters was developed for different facility types and traffic control methods.

The SAM-V2.5 feeds the congested highway travel times produced in the traffic assignment step back to the trip distribution model. The feedback procedure uses the method of successive averages (MSA) with convergence based on changes in link volumes between iterations.

Expansion to Five states

The SAM-V2.5 passenger models were expanded to cover Texas' four neighboring states - Louisiana, Arkansas, Oklahoma and New Mexico in order to support the TxDOT passenger rail study. The passenger model expansion involves the following components:

- Zonal structure and network
- Demographics estimates and forecasts
- Household sub-models and household regional distribution
- Special generators
- Externals
- Addition of egress and modes in the transit skimming process and the mode choice model structure
- Addition of reliability measures in the utility function for rail and air modes
- Investigating the impact of frequency of service and convenience of departure time on mode choice

The zonal structure, network and demographics are the required inputs for the expanded model area, which is described in detail in the other model reports. The household sub-models in the original SAM-V2 passenger models were developed solely based on Texas demographic data. This data was not necessary to best fit the expanded five state area and therefore the household sub-models and regional household distribution were re-estimated for the five state area using the American Community Survey (ACS) data. The special generators are identified for the four neighboring states using the same criteria as SAM-V2. The expansion inevitably brings change to the external stations. The external stations in the original SAM-V2 model are now internal zones and new external stations were identified for the new boundary of the five-state model area. In addition, due to data limitations and the new characteristics of the External-to-External trips for the five-state area compared to SAM-V2, the methodology for estimating external trips was revised.

Because the neighboring four states did not participate in the 2009 NHTS add-on program and the national sample for the four states did not provide enough detail to analyze the trip characteristics that were modeled by the SAM-V2, the Texas daily travel patterns were applied to the expanded model area.

Data Updates

Multiple components of the SAM-V2.5 model were updated with current data sources. The sections below describe several of these updates.

Socioeconomic Data

The socioeconomic data serves both the passenger and freight trip generation models. Employment data is maintained at the two-digit North American Industry Classification System (NAICS) level except for the manufacturing sector, where employment is maintained at the three-digit NAICS level.

Forecast years for the socioeconomic data included in the standard distribution of the model include 2010, 2020, 2030, and 2035. The processes used to estimate population and employment variables at the SAM-V2.5 TAZ level were all based on the US Census year 2000 block geography data. The socioeconomic base year and forecast data for all five states were updated using data from:

- U.S. Decennial Censuses
- U.S. Census Bureau's American Community Survey (ACS)
- Individual Metropolitan Planning Organization (MPO) Population and Employment Forecasts
- U.S. Census Bureau's County Business Patterns (CBP)
- U.S. Bureau of Labor Statistics Quarterly Census of Employment and Wages (QCEW)
- U.S. Bureau of Economic Analysis' Regional Economic Information System (REIS)
- Texas Workforce Commission (TWC)
- LEHD Origin-Destination Employment Statistics (LODES)
- Woods & Poole 2010 Complete Economic and Demographic Data Source (CEDDS)

Networks

A master network geography is maintained for all years and modes. Individual years or mode networks (e.g. rail) can be extracted, enabled, or disabled with selection sets depending on needs. The following mode-specific networks are contained within the master network layer:

- Roadway,
- Passenger rail,
- Passenger air routes,
- Passenger high-speed rail,
- Freight rail, and
- Freight waterways.

The following elements of the SAM-V2.5 network were revised for the Statewide Ridership Analysis.

Road Network

- Posted Speed: Recent speed limit changes on Texas interstates and freeways
- Future Projects: Major existing and future roadway projects from TX, AR, LA, NM, and OK
- HOV/HOT Lanes: HOV and HOT lanes from the Houston and Dallas metropolitan areas
- Toll Roads: Toll rates on existing and future roadways
- Grade Separations: Grade separated intersections in AR, LA, NM, and OK
- Traffic Counts: Internal and External Annual Average Daily Traffic (AADT) and Automatic Vehicle Classification (AVC) traffic counts in TX, AR, LA, NM, and OK

Other Modal Networks

- Intercity Passenger Rail: Amtrak routes added in TX, AR, LA, NM, and OK
- Urban Passenger Rail: Urban rail routes added in TX, AR, LA, NM, and OK
- High Speed Passenger Rail: High speed rail routes added in TX, AR, LA, NM, and OK
- Air Routes: Air routes added in TX, AR, LA, NM, and OK

Additional detail about these modifications can be found in the Model Development Report.

Use of ALPS Data

The SAM-V2.5 model uses the Advanced Land-Transportation Performance Simulation (ALPS) model to better define the urban area interfaces and conditions. This was accomplished by using the ALPS results designed and output to be compatible with the SAM-V2.5 to:

- Review the reasonableness of air passenger activity estimates at airports with the data produced from flight schedule processing performed in support of ALPS.
- Review and refine the urban passenger rail facilities (i.e., routes and stops) input into the SAM-V2.5 using urban passenger rail route information output from ALPS with the goal of improving the correlation of passenger activity in the peak and off-peak time periods.
- Review travel to/from intercity passenger rail intermodal stations and airports, which represent travel time and cost parameters associated with the access and egress components of a trip within the terminal or station property.

Specifically, regarding the components of travel within or at terminals and stations, ALPS data was used to confirm and verify input assumptions in a few ways:

- The Houston airport distribution of processing time through airport functional areas (as in the Table below from the HGAC ALPS report) was used to derive part of out-of-vehicle time as mode choice inputs. Similar tables for airports of different sizes are available from additional ALPS reports.

Table 1: HOU Airport Distribution of Processing Time through Airport Functional Areas

Originating Passengers		Terminating Passengers	
Process	**Time (min.)**	**Process**	**Time (min.)**
Parking/Access	13.4	Exit Plane/Secure Area	16.7
Ticketing	20.2	Baggage Claim	25
SSCP	33.6	Parking/Egress	13.9
Gate Area/Boarding	67.2	Total	55.5
Total	134.4		

- The parking cost assumptions made by ALPS at airports and rail stations were reviewed.

Additional information about the use of the ALPS models in the SAM-V2.5 development can be found in the ALPS Model Development Report.

Validation

Validation refers to the process of using a calibrated model to estimate travel for the base year and then comparing the model's output to observed travel data. The validation of the SAM-V2.5 included the validation of passenger trip generation, passenger trip distribution, passenger mode choice, and passenger and freight trip assignment for all modes of transportation. However, during SAM-V2.5 development, all steps of the freight model were independently validated as well.

Care was taken with each model step to ensure that the Travel Demand Model maintains a high level of predictive value. To this end, the model contains no subjective adjustment factors. All changes and adjustments to model parameters were performed in a comprehensive and systematic manner, and were applied uniformly and consistently across the entire model. The resulting model provides a realistic and reliable predictor of magnitude and pattern of future travel in Texas and surrounding states. It should serve as a useful and informative tool for performing travel forecasts and analyses of proposed transportation projects.

Trip Generation

Trip rates were calculated from the *2009 National Household Travel Survey (NHTS)* Texas add-on sample and urban area household surveys, as reported in *Urban Travel in Texas* (Texas Transportation Institute, The Texas A&M University System, 1996), which were utilized in trip generation validation. The percentage of trips by seven trip purposes estimated for the SAM was compared to the percentage reported in the *NHTS* and *Urban Travel in Texas*.

Trip Distribution

The primary method used to validate the trip distribution model is to compare the trip length by trip purpose and income group between the model and the observed data. The trip length is checked for time (in minutes) across all trip purposes and income groups.

Mode Choice

Validation and reasonableness checking of mode choice models involves comparison of mode shares by trip purpose produced by the SAM-V2.5 to observed survey data through the use of the 2009 *NHTS* data.

Trip Assignment

Validation of the model to observed flows is important to the modeling effort in two regards. First, the validation shows whether the calibration tools used in the model process and assumptions were reasonable. Second, the validation shows what level of confidence the user can have in the forecast results.

The typical comparison for highway validation, when sufficient data is available, is between highway traffic assignments and actual traffic volumes derived from traffic count data. A similar measure, vehicle miles of travel (VMT), is calculated from the same traffic counts and the length of the roadway on which the count is located. Extensive traffic counts were available to validate the SAM-V2.5.

The model validation procedure used for the SAM-V2.5 was similar to the procedure used by state DOTs and MPOs throughout the country. The locations of year 2010 traffic counts provided by the TxDOT were coded to the roadway networks. Traffic assignment results for the validation year (2010) were compared to these traffic counts by three indices: Percent of Count, Correlation Coefficient, and Percent Root Mean Squared Error (%RMSE), each of which was aggregated and tabulated across a variety of categories. Percent of Count was used to measure the overall difference between modeled and counted flows. The Correlation Coefficient estimated the correlation between the actual ground counts and the estimated traffic volumes. Percent Root Mean Squared Error (%RMSE) was used to measure the difference between modeled flows and counted volumes on a link-by-link basis, which gave a better picture of the “closeness” between model flows versus counts.

The assignment of high speed intercity passenger rail trips within the SAM-V2.5 were not specifically examined during the validation process. The validation process compares the model output for the base year to existing count data. Because there are no existing high speed intercity passenger rail facilities within the SAM-V2.5 study area in 2010, no high speed intercity passenger rail facilities were specifically validated. However, substantial sensitivity testing and probability analysis were conducted to ensure that the high speed intercity passenger rail ridership results were realistic and reasonable.

Sensitivity Testing

To carry out the sensitivity analysis, a series of travel demand model runs were conducted using the draft SAM-V2.5. The initial round of sensitivity tests was run using the 2010 model Base Year, with a surrogate, or straw man, high speed intercity passenger rail service component incorporated into the existing transportation system. Once the battery of sensitivity tests for level-of-service variables had been completed for the Base Year condition, an additional test to examine model performance in a forecast year was conducted to examine responses in model performance to changes in model inputs.

Using the Base Year as the test case allowed for initial testing of model sensitivity without the bias that could be introduced by forecasting methodology or other factors such as inflation rates or discount rates.

Results and Relationships of Variables

Sensitivity testing was conducted for the intercity passenger rail level of service attributes later described in section 2 of this report in order to evaluate the attributes' relative elasticity. This testing was done to evaluate the potential impact of changes in the level of service parameters, and to evaluate the reasonableness and validity of the SAM-V2.5 mode choice model.

Elasticity Analysis

Following the mathematical derivation of the elasticity for the independent variables in the SAM-V2.5 passenger mode choice model, the direct elasticity and cross-elasticity were calculated with respect to each independent variable.

Direct elasticity values are interpreted as the percent effect that a 1% change in the independent variable has on the likelihood of a specific alternative being chosen. If the computed elasticity is less than one, then the variable is said to be inelastic because a 1% change will result in less than 1% of the change in the probability of choosing the specific alternative. If the elasticity is greater than one, then the variable is said to be elastic because a 1% change in the variable will result in more than 1% of change in the probability of choosing the specific alternative.

The cross-elasticity measures the change on a variable resulting from a 1% change in a different, related variable. If the computed cross-elasticity is negative, it means that the two alternatives are complementary; if the computed cross-elasticity is positive, it means the two alternatives are substitutive.

Model Runs

To check the reasonableness and sensitivity of the SAM-V2.5 prediction on mode choice, four scenarios were run with different settings provided by the project team on the potential intercity passenger rail routes. The following table briefly describes and compares the differences in the four test scenarios.

Table 2: Modeling Scenarios

Scenario	Passenger Rail Routes	Fare	Avg. Speed
High Fare 2010	3	Highest (comparable to **AIR**)	150 mph
Low Fare 2010	3	Lowest (comparable to **Drive Alone**)	150 mph
Mid-Range 2010	3	Medium (federal mileage route * route distance)	80 mph
High Fare 2035	3	Highest (comparable to **AIR**)	150 mph

All mode shares were compared to the adjustments to the intercity passenger rail service levels and the results were analyzed to determine what impact the intercity passenger rail service levels have on mode shift by determining which modes were most and least sensitive to the intercity passenger rail mode. The results from this general comparison appear reasonable, which indicates the current mode choice model performs as intended.

Corridor Level Comparison

Finally, the sensitivity tests were evaluated at the corridor level. These sensitivity tests used the results from the SAM-V2.5 model runs in each of the four scenarios previously described to evaluate the impact of the shift in mode share in response to intercity passenger rail level of service modifications at a more aggregate level with a mixture of Origin/Destination (OD) pair characteristics and travel demand. Several corridors, listed below, were included in the sensitivity testing.

- Dallas- Fort Worth to Houston
- Dallas- Fort Worth to Austin
- Dallas- Fort Worth to Oklahoma City
- Dallas- Fort Worth to San Antonio
- Austin to San Antonio
- Dallas- Fort Worth to Killeen/Temple
- College Station to Houston

The results of the model runs were again compared to the adjustments to the HSR corridors to determine the impact of the shift in mode share. The results of this analysis reflected what was seen in the elasticity analysis and reflected the stability of the mode choice model performance across scenarios.

Conclusions

Based on the previous findings in the sensitivity analysis, the mode choice model appears to be sensitive to changes in modal scenarios, and is performing well. However, the model can be further refined to enhance the model's predictive capabilities, as well as to provide additional sensitivity to some market segments. Additional details about the model development can be found in the Model Development Report.

3.0 Levels-of-Service Assumptions and Forecast Alternatives

The origin and destination cities (city pairs), as well as the level of service characteristics for the various corridors to be analyzed in the Statewide Ridership Model, were determined using the methodology outlined as follows.

Evaluation of City Pairs

The methodology used to determine the city pairs to be analyzed in the Statewide Ridership Model began with a review of previous studies conducted that identify and prioritize potential passenger rail corridors in Texas. The three primary works referenced to develop the city pairs are briefly summarized below.

Potential Development of an Intercity Passenger Transit System in Texas, Texas Transportation Institute (TTI), February 2010

The TTI report discusses existing transit services in Texas and identifies and ranks 18 potential intercity corridors for passenger rail services. The analysis focused on current and future demographic projections, projected future demand, current transportation network capacity, and intercity roadway, air, bus, and rail travel, and weighted all evaluations factors equally when applying a ranking to each corridor. Order-of-magnitude construction costs were also calculated for each corridor for speeds up to 79 MPH, 110 MPH, and greater than 110 MPH; these costs were not included as part of the ranking analysis.

Of the 18 city pairs, the Dallas-Fort Worth to San Antonio and the Dallas-Fort Worth to Houston corridors were considered the priority corridors based on rankings. The next highest-ranked corridors included Dallas-Fort Worth to El Paso via Abilene, Dallas-Fort Worth to Lubbock via Abilene, Houston to Austin, and Houston to Beaumont. The lowest-ranked corridors included Amarillo to Midland/Odessa via Lubbock and San Antonio to Brownsville via Corpus Christi.

Performance Measures for Prioritizing Passenger Rail in Texas, Center for Transportation Research (CTR), January 2010

The CTR report specifies seven specific performance measures for evaluating passenger rail in Texas: travel demand, capacity, diversified investment, travel time, route planning, intermodal, and environment/land use. These particular performance measures were developed through federal and state governments as well as organizations with interest in proposed intercity passenger rail systems.

Travel demand for the cities within the Texas Triangle region formed by Dallas-Fort Worth, Houston, and San Antonio (including Austin and Waco) seemed the most likely to have sufficient ridership for successful passenger rail service, according to the study. Similarly, the implementation of passenger/high-speed rail service in the Texas Triangle region could provide additional capacity for roadway and airports that are anticipated to be overburdened operationally, as well as the potential for air/rail integration. Travel times based on the Texas TGV project for high-speed rail in the Texas Triangle generally appear to be more efficient than automobile but not as efficient as air travel, the exceptions being in the Austin – San Antonio corridor.

America 2050: Where High Speed Rail Works Best, September 2009

The America 2050 report, *Where High Speed Rail Works Best,* defines and ranks the corridors most appropriate for high-speed rail based on the greatest ridership demand between city pairs within the United States. The city pairs were evaluated based on metropolitan size, distance between the cities, available transit connectivity, economic productivity, and congestion. The Dallas to Houston corridor was ranked 10th and the Austin to Dallas corridor was ranked 45th in terms of the greatest demand for a high speed rail system based on the following factors.

- Metropolitan size - High speed rail systems located in major metropolitan areas have higher travel demand.
- Distance - The evaluation prioritized city pairs that were 200 to 300 miles apart based on the assumption that longer distances are more efficiently traveled by air and shorter distances are better travelled by automobile.
- Transit Connections - “High-speed rail systems will attract greater numbers of riders if they begin and end in central locations within the metro region and tie seamlessly into existing commuter rail and transit systems.”
- Economic Productivity - “High-speed rail systems depend heavily on business travel to sustain ridership and business travel is highest in places with more productive economies.”
- Congestion - Congestion reduction at airports and on highways is a goal for building high speed rail lines.

Statewide Ridership Analysis Methodology

The methodology for this study utilized the common measures of population, travel demand, and corridor distance from the studies listed above to evaluate the potential city pairs. The TTI study utilized population as well as travel demand; the CTR study identified travel demand and travel time (as a function of distance); and the America 2050 study looked at metropolitan size and distances.

The city pairs analyzed in the Statewide Ridership Model were evaluated independently for three different levels of service, based on the definitions contained in the National High Speed Rail Strategic Plan as summarized below.

- Core Express Service

  - Maximum speeds between 125 and 250 mph
  - Frequent, express service between major population centers 200 to 600 miles apart with few, if any, intermediate stops
  - Located on dedicated right of way, with the exception of potential shared use tracks in terminal urban areas
  - Fully grade-separated corridor
- Regional Service
  - Maximum speeds between 90 and 125 mph
  - Relatively frequent service between major and moderate population centers 100 to 500 miles apart with some intermediate stops
  - Located on some dedicated and some shared use track, generally following existing rail corridors
- Emerging/ Feeder
  - Maximum speeds up to 90 mph
  - Developing corridors of 100 to 500 miles, with strong potential for future regional or core express service
  - Located primarily on shared track

Potential city pairs evaluated in the ridership model for each service level were determined independently based on the criteria for each level of service utilizing a tiered analysis that filtered potential cities based on population, corridor distance, and corridor travel demand, as described in further detail as follows.

Core Express Service

The city pairs tested in the model to determine potential ridership for core express service were identified utilizing the tiered process illustrated in Figure 1.

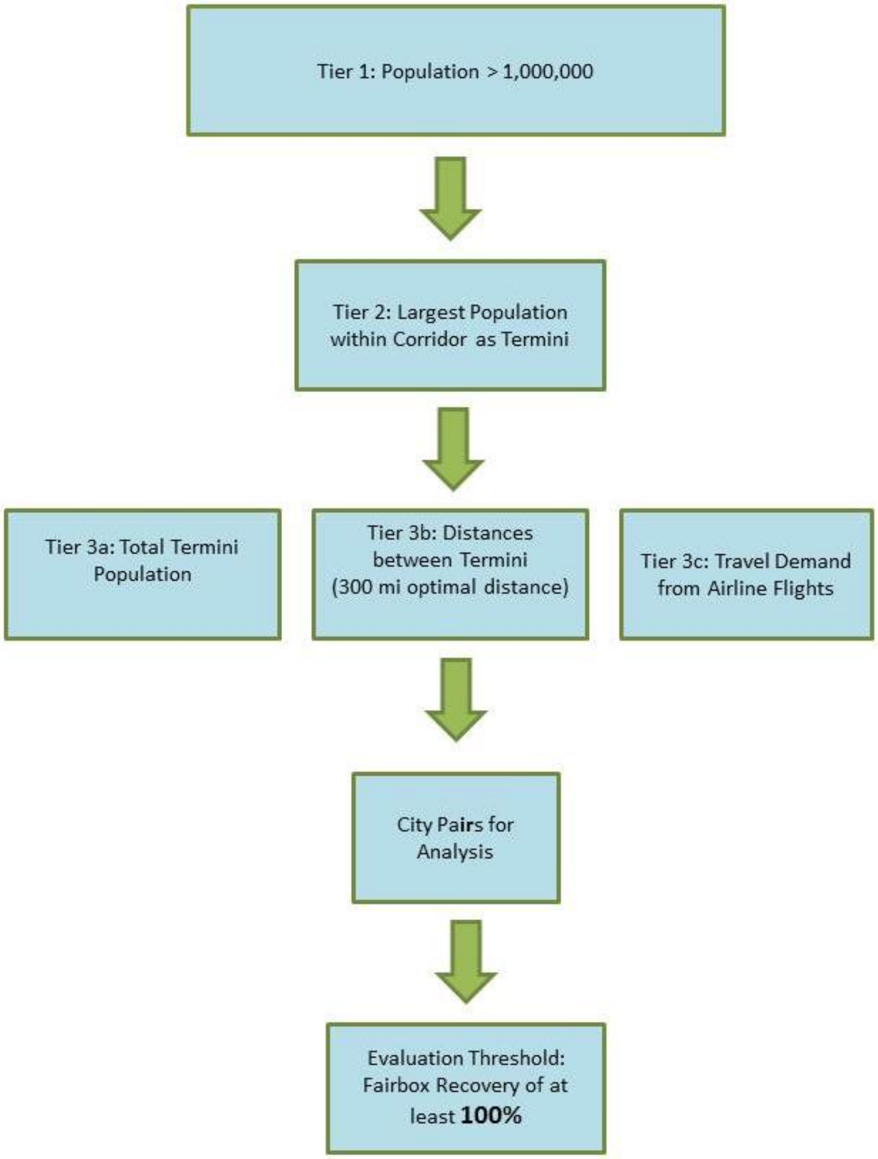

Figure 1: Evaluation Process to Identify City Pairs to be Evaluated for Core Express Service Ridership

Tier 1: Population Density of Metropolitan Statistical Areas (MSAs)

The potential list of city pairs started with all Metropolitan Statistical Areas (MSAs), which are defined as regions with a relatively large population density (at least 50,000 people) at its core, within the state of Texas as well as the MSAs of Baton Rouge, Shreveport/ Bossier City, Little Rock, Oklahoma City, and Albuquerque from adjacent states. Populations of the MSAs were identified utilizing U.S. Census Bureau data. MSAs with higher populations are assumed to produce a higher travel demand through a larger base of potential riders and generally higher population densities in a particular city area. Tier 1 of this methodology narrowed down the list of potential city terminus points for intercity passenger rail to MSAs with populations of greater than one million persons. It should be noted that, while the minimum population criterion of one million eliminated Baton Rouge as a potential core express route terminus for the modeling, if New Orleans were to be included in the analysis, routes through Baton Rouge (such as New Orleans to Houston) may warrant core express service.

Tier 1 of the analysis narrowed down the list of potential city termini from 29 MSAs to 5 MSAs that were moved forward to Tier 2 in the evaluation as listed in Table 3.

Table 3: MSAs for Use in Core Express City Pair Analysis

Metropolitan Statistical Area (MSA)	Abbreviation	Population (2011)
Austin-Round Rock-San Marcos, TX	AUS	1,783,519
Dallas-Fort Worth-Arlington, TX	DFW	6,526,548
Houston-Sugar Land-Baytown, TX	HOU	6,086,538
Oklahoma City, OK	OKC	1,278,053
San Antonio-New Braunfels, TX	SAN	2,194,927

Tier 2: Largest MSAs within Corridor as Termini

Tier 2 looked at the populations of the potential corridor termini as well as the MSAs along the corridor's route of the city pairs that met Tier 1 criteria. Corridors that include a MSA population within the corridor larger than the termini of the corridor were removed from consideration. This removed potential overlap of corridors with larger MSAs within the city pair; however, the shorter route utilizing the larger MSA (without the larger MSA inside of the termini points) was still considered as a city pair for analysis.

Tier 2 of the analysis narrowed down the list of potential city pairs from the 5 MSAs from Tier 1 to seven city pairs which were moved forward to Tier 3 in the evaluation, as listed in Table 4. City pairs with both termini points outside of Texas (e.g., Albuquerque to Oklahoma City) were not included. The remaining city pairs were then ranked from one to seven for each of the three criterion in Tier 3 of the evaluation: total population of the termini cities, distance between termini, and travel demand within the corridor.

Table 4: Potential Core Express City Pairs for Tier 3 Analysis

Terminus 1	Terminus 2
AUS	DFW
AUS	HOU
AUS	SAN
DFW	HOU
DFW	OKC
DFW	SAN
HOU	SAN

Tier 3a: Total Termini Population

The populations at the termini serve as the greatest factor for potential intercity passenger rail ridership. The seven potential city pairs, ranked by total termini population, are shown in Table 5.

Table 5: Potential Core Express City Pairs Based on Total Population of Corridor

Terminus 1	Terminus 2	Total Pop	Pop Rank
DFW	HOU	12,613,086	1
DFW	SAN	8,721,475	2
AUS	DFW	8,310,067	3
HOU	SAN	8,281,465	4
AUS	HOU	7,870,057	5
DFW	OKC	7,804,601	6
AUS	SAN	3,978,446	7

Tier 3b: Distances between MSAs

Corridor distances generally considered appropriate for high-speed passenger rail range from 200 to 600 miles in length, with 200- to 300-mile corridors being optimal based on the assumption that longer distances are more efficiently traveled by air and shorter distances are better travelled by automobile or commuter rail. Tier 3b ranked the city pairs based on the corridor distances between the termini, with an optimal distance of 300 miles, as stated in the America 2050 report previously referenced. The corridor distances were approximated based on existing major highway routes or existing Amtrak routes between the city central business districts, since alignments for potential passenger rail service have not yet been identified.

The seven potential city pairs, ranked by distance between MSAs, are shown in Table 6.

Table 6: Potential Core Express City Pairs Based on Distance between Termini

Terminus 1	Terminus 2	Distance	Rank
DFW	SAN	272	1
DFW	HOU	251.5	2
DFW	OKC	205.5	3
HOU	SAN	197	4
AUS	DFW	193	5
AUS	HOU	165	6
AUS	SAN	81	7

Tier 3c: Travel Demand from Airline Flights

Each city pair has a travel demand from multiple transit modes, including automobile, bus, air, and passenger rail. Tier 3c evaluated the current travel frequency of airline flights to identify potential travel demand for the intercity passenger rail city pairs that met Tier 2 criteria. It was assumed that a certain percentage of the ridership for the intercity passenger rail corridors would come from this travel mode, and that a higher amount of travelers within a particular corridor denotes a higher potential ridership for the intercity passenger rail corridor.

A particular travel date was chosen for use to determine nonstop flights between city pairs. Capacities of airplanes were assumed as 140 based on typical seat availability. The average annual daily traffic (AADT) between corridors was not used as part of this analysis since specific origin and destination data for AADT between the city pairs was not available at this stage of development.

The 7 potential city pairs, ranked based on travel demand, are shown in Table 7.

Table 7: Potential Core Express City Pairs Based on Travel Demand

Terminus 1	Terminus 2	Total Flights	Rank
DFW	HOU	108	1
DFW	SAN	58	2
AUS	DFW	54	3
AUS	HOU	28	4
HOU	SAN	28	5
DFW	OKC	24	6
AUS	SAN	0	7

Tier 4: Identification of City Pairs for Statewide Ridership Model

The Tier 4 analysis highlighted the results from the Tier 3a, 3b, and 3c reviews and determined potential city pairs to be evaluated in the Statewide Ridership Model based on those results. Table 8 and Figure 2 show the results from the Tier 3a, 3b, and 3c analysis showing the highest and lowest rankings and the average ranking, assuming equal weighting for each category, for each city pair.

Table 8: Results of Tier 3 Analyses and Highest/Lowest Overall Rankings for Core Express Service

Terminus 1	Terminus 2	Rank			Rank (Avg)
		Distance	Population	Travel Demand	
DFW	SAN	1	2	2	1
DFW	HOU	6	1	1	2
AUS	DFW	10	3	3	3
HOU	SAN	9	4	6	4
AUS	HOU	12	5	6	5
DFW	OKC	8	6	9	5
AUS	SAN	14	14	17	6

Compared with the TTI and America 2050 corridors, the DFW-SAN, DFW-HOU, and HOU-SAN city pairs ranked in the top 5 for all 3 lists. Similarly, AUS-HOU and DFW-OKC also made the top 10 in each list; however, it should be noted that TTI did not extend its study limits to city pairs outside of Texas.

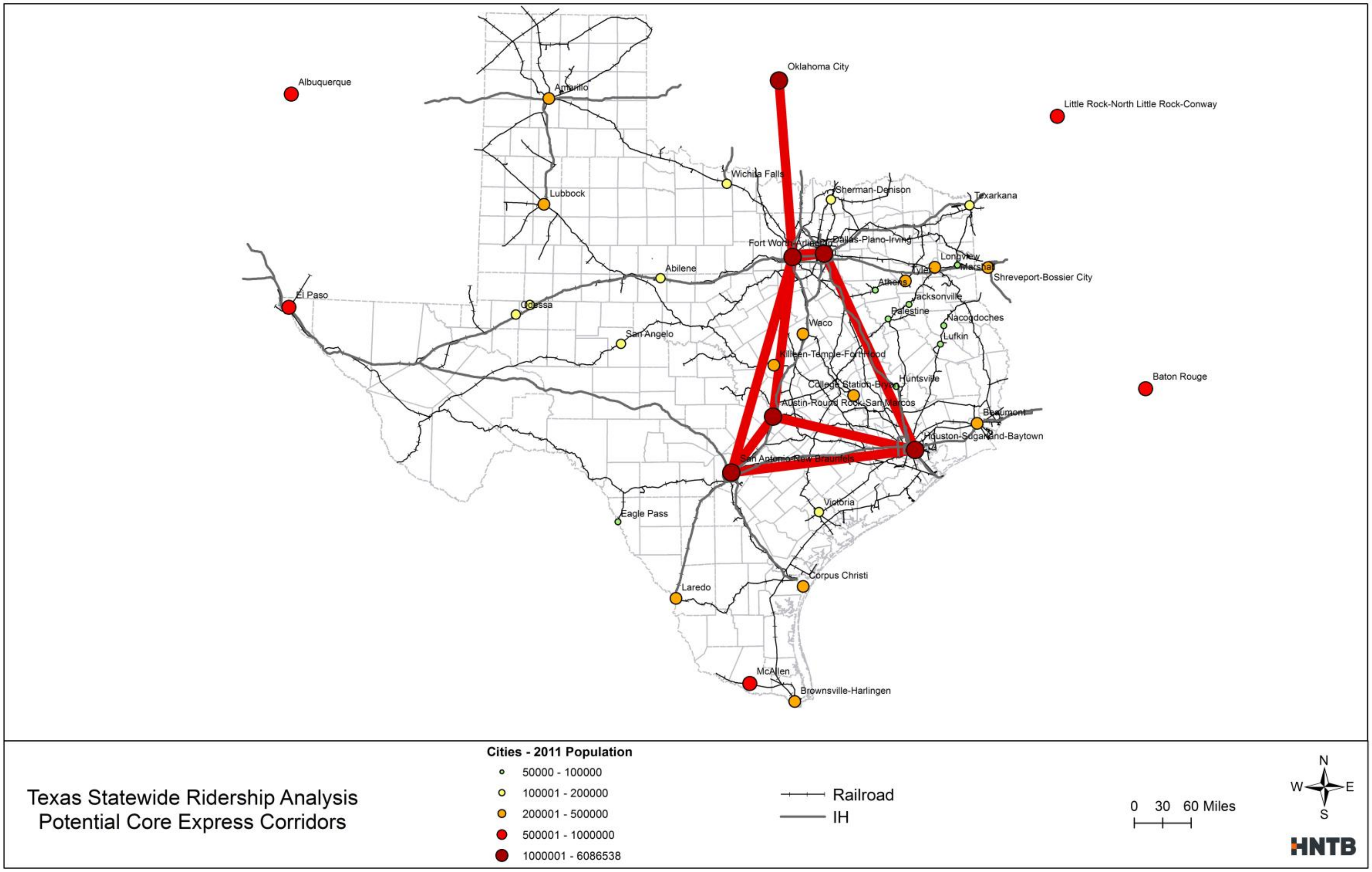

Figure 2: Potential Core Express Service Corridors

The corridors listed in Table 8 were tested in the Statewide Ridership Model to determine potential ridership and cost recovery to evaluate if core express service is economically justified. The corridors will be tested starting from the top of the list until a cost recovery threshold initially assumed to be a 100% farebox recovery ratio is no longer reached, at which point the remaining corridors will not be tested for core express service. The farebox recovery ratio is the percentage of a passenger rail system's operating and maintenance costs that are paid for by the fees charged to ride the system. The remaining corridors that did not meet the farebox recovery threshold were then tested based on the results of the evaluation utilized to determine potential city pairs for regional service described as follows.

<u>Regional and Emerging Service</u>

The potential city pairs tested in the model to determine potential ridership for regional service were identified utilizing the tiered process illustrated in Figure 3.

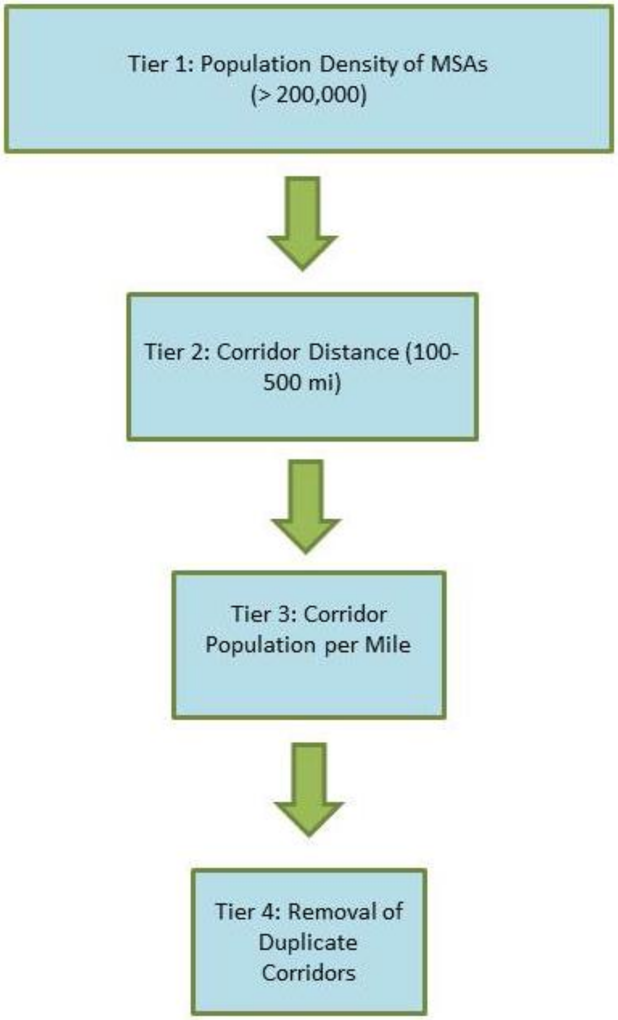

Figure 3: Evaluation Process to Identify City Pairs to be Evaluated for Regional Service Ridership

Tier 1: Population Density of Metropolitan Statistical Areas (MSAs)

Tier 1 of this methodology narrowed down the list of potential city terminus points for intercity passenger rail to MSAs with populations of greater than 200,000 persons. Tier 1 of the analysis narrowed down the list of potential city termini to 22 MSAs (220 city pairs) which were moved forward to Tier 2 in the evaluation as listed in Table 9.

Table 9: MSAs for Use in Regional City Pair Analysis

Metropolitan Statistical Area (MSA)	Abbreviation	Population (2011)
Albuquerque, NM	ABQ	898,642
Amarillo, TX	AMA	253,823
Austin-Round Rock-San Marcos, TX	AUS	1,783,519
Baton Rouge, LA	BAT	808,242
Beaumont-Port Arthur, TX	BEA	390,535
Brownsville-Harlingen, TX	BRO	414,123
College Station-Bryan, TX	COL	231,623
Corpus Christi, TX	CRP	431,381
Dallas-Fort Worth-Arlington, TX	DFW	6,526,548
El Paso, TX	ELP	820,790
Houston-Sugar Land-Baytown, TX	HOU	6,086,538
Killeen-Temple-Fort Hood, TX	KIL	411,595
Laredo, TX	LAR	256,496
Little Rock-North Little Rock-Conway, AR	LR	709,901
Longview, TX	LON	216,666
Lubbock, TX	LUB	290,002
McAllen-Edinburg-Mission, TX	MCA	797,810
Oklahoma City, OK	OKC	1,278,053
San Antonio-New Braunfels, TX	SAN	2,194,927
Shreveport-Bossier City, LA	SHR	403,595
Tyler, TX	TYL	213,381
Waco, TX	WAC	238,564

Tier 2: Corridor Distance

City pairs with total corridor distances less than 100 miles or greater than 500 miles were eliminated, which narrowed down the list of potential city pairs from 220 to 132 corridors that were moved forward to Tier 3 of the analysis.

Tier 3: Population per Mile of Corridor

The populations at the termini as well as cities with populations greater than 100,000 people along the corridor were calculated for each of the potential city pairs. Additionally, the corridor distance generally following existing rail corridors or, in some cases, short segments of new track were estimated for each city pair. The city pairs were then ranked based on the corridor population per mile to compare the city pairs based on potential ridership and level of investment. Additionally, population per mile along a route has proven in various existing passenger rail systems to correlate with the farebox recovery ratio.
The top 25 of the remaining potential city pairs, ranked based on corridor population per mile, are shown in Table 10.

Table 10: Potential Regional City Pairs Based on Population of Corridor per Mile

Terminus 1	Terminus 2	Pop/MI	Pop/MI Rank
COL	DFW	39,292	1
DFW	SHR	36,275	2
HOU	KIL	34,869	3
HOU	WAC	34,780	4
HOU	TYL	31,818	5
CRP	HOU	31,488	6
OKC	SAN	30,116	7
HOU	LON	29,920	8
HOU	SHR	28,550	9
HOU	LAR	26,934	10
DFW	LAR	26,879	11
OKC	TYL	26,638	12
LON	OKC	24,354	13
LON	SAN	24,134	14
KIL	OKC	24,013	15
BEA	CRP	23,988	16
BEA	DFW	23,976	17
AUS	BAT	22,280	18
DFW	LUB	22,204	19
DFW	LR	21,601	20

Terminus 1	Terminus 2	Pop/MI	Pop/MI Rank
BAT	SAN	21,352	21
HOU	MCA	20,448	22
AMA	DFW	19,154	23
AUS	COL	18,833	24
CRP	DFW	18,579	25

Tier 4: Removal of Duplicate Corridors

Tier 4 removed city pairs that would be served by the potential core express corridors as well as overlapping corridors such as Oklahoma City to San Antonio and Dallas-Fort Worth to San Antonio. In the case of overlapping corridors, the longest corridor was retained while the shorter corridor options were removed and ridership outputs by corridor segment were produced in the model. The overlapping corridors that were contained in the top 25 of the city pairs listed in Table 10 were then replaced by the longer corridor along those same routes. For example, Corpus Christi to Houston was replaced by Beaumont to Brownsville. The resulting top 25 corridors for potential regional service evaluated in the model are listed in Table 11.

Lastly, three potential corridors were added to the list that would provide service to El Paso, since it was the only major metropolitan area in Texas that would not be served based on the methodology utilized to determine the potential city pairs as described.

The resulting corridors are listed in Table 11 and shown in Figure 4.

Table 11: Potential Regional Corridors Based on Population of Corridor per Mile

Terminus 1	Terminus 2	Rank
COL	DFW	1
DFW	BAT	2
HOU	KIL	3
HOU	WAC	4
HOU	TYL	5
BEA	BRO	6
OKC	SAN	7
HOU	LON	8
HOU	LR	9
BEA	LAR	10
DFW	LAR	11
OKC	TYL	12
LON	OKC	13
LON	SAN	14
KIL	OKC	15
BEA	MCA	16
BEA	DFW	17
AUS	BAT	18
LUB	TYL	19
DFW	LR	20
BAT	SAN	21
ABQ	DFW	22
COL	SAN	23
DFW	MCA	24
ELP	DFW (via Midland-Odessa)	25
ELP	DFW (via San Angelo)	25
ELP	AUS	25
ABQ	ELP	25

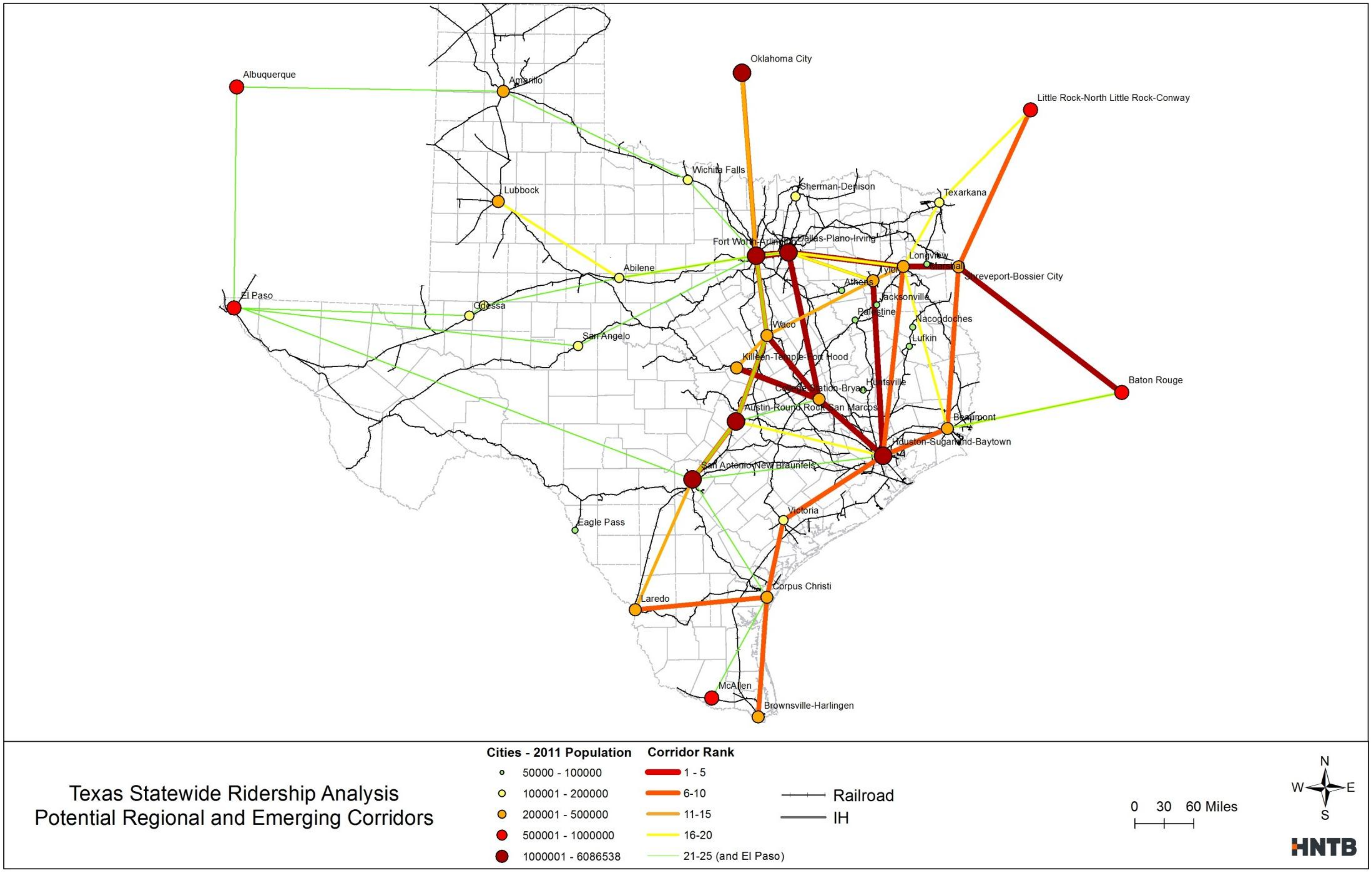

Figure 4: Potential Corridors for Regional and Emerging Service

The top 25 corridors were tested starting from the top of the list until a cost recovery threshold initially assumed to be a 75% (or slightly below) farebox recovery ratio was no longer reached, at which point the remaining corridors were tested for emerging service until a farebox recovery ratio of 50% (or slightly below) was no longer reached. The assumed farebox recovery ratio threshold may be adjusted based on the modeling results.

Figure 5 shows the potential core express, Regional, and Emerging corridors evaluated in the ridership model as previously described.

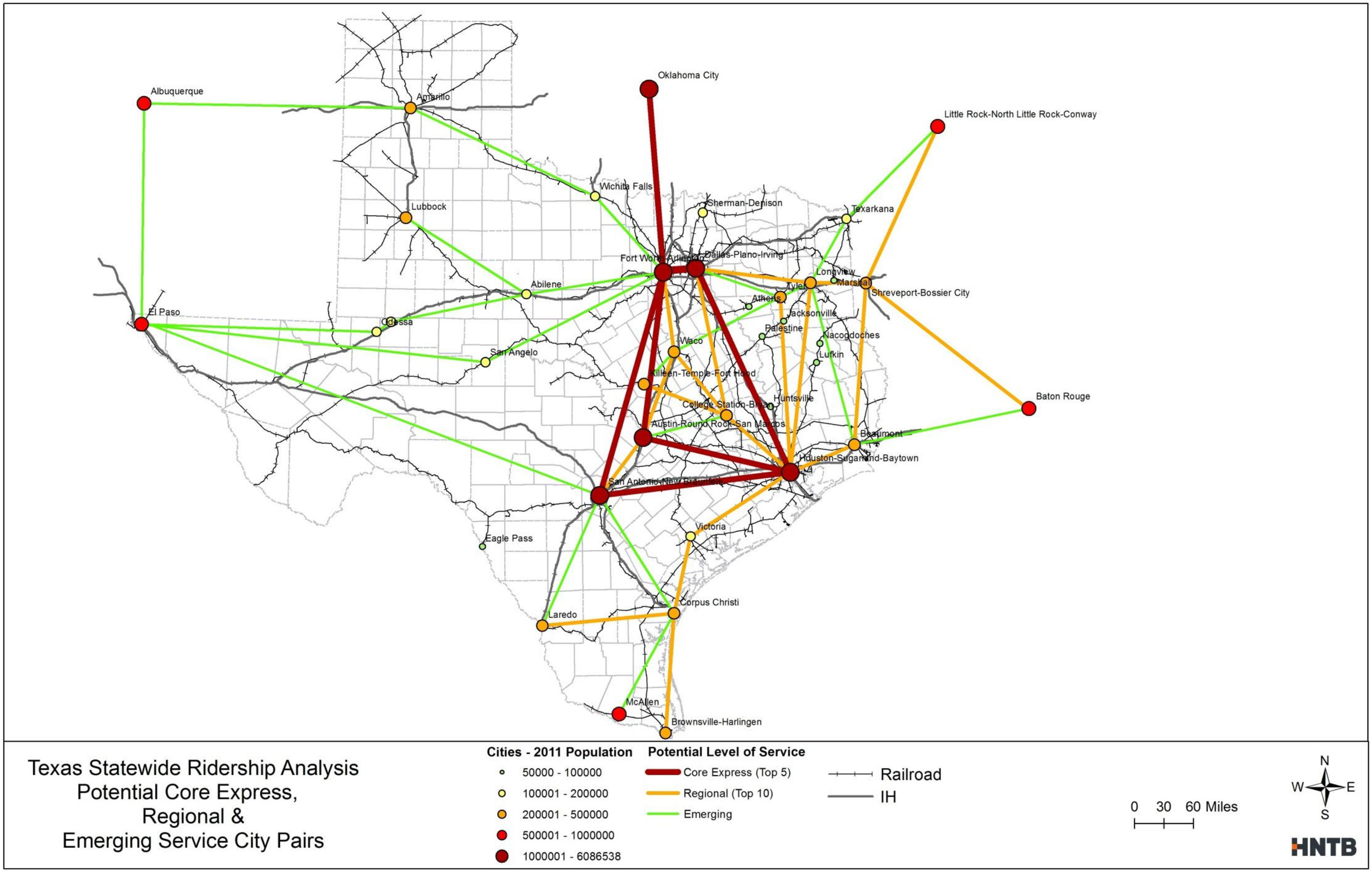

Figure 5: Potential Corridors for Core Express, Regional, and Emerging Service

Service Level Criteria Assumptions

The characteristics that distinguish the levels of service tested in the Statewide Ridership Model and the associated estimated costs were defined by the following assumptions based on similar operating systems.

Average Operating Speed

The average operating speeds assumed for the purpose of determining estimated trip times in the ridership model were based on the maximum allowable speeds along the route reduced to account for acceleration and deceleration, station stops, and potential curve restrictions. However, operations modeling was not performed for the potential passenger rail corridors and the assumed average operating speeds do not account for corridor-specific congestion (train meets/ capacity constraints) or any known topography or geometry.

- Core Express – 150 mph (250 mph max speed)
- Regional – 75 mph (125 mph max speed)
- Emerging – 40 mph (90 mph max speed with PTC)

Type of route

The type of route assumed between the city pairs for the purpose of determining route distance was based on the infrastructure requirements for each level of service. For example, core express service requires a fully grade separated corridor, while regional service typically requires new track with an offset of at least 50 feet from existing freight tracks. Emerging service can operate on existing freight tracks, though positive train control (PTC) signal systems would be required for operating speeds greater than 79 mph. In cases where multiple route options may be available (e.g., Houston to Little Rock through Beaumont and Shreveport versus through Longview), the route with the greatest population base for ridership was assumed.

- Core Express – greenfield
  - Route distance based on shortest highway route
- Regional – mostly existing corridors with new tracks adjacent to existing with some new greenfield sections where existing tracks do not provide reasonable routes between cities
  - Route distance based on track charts with total distance reduced by 5% to account for curve reductions and greenfield sections were based on shortest available highway routes
- Emerging – shared-use with existing freight lines

  - Route distance based on existing track between city pairs

Station Stops

The number of stops and spacing of stops varies based on the level of service in order to maintain trip times appropriate for each type of service. For example, the number of stops along a core express route must be kept to a minimum in order to maintain the high speeds and short trip times to be competitive with flight service.

- Core Express – only stops at termini and major metropolitan areas (population > 500,000)
  - Some exceptions were made in locations where several populations were located in near proximity that would aggregate to approximately 500,000 or more (e.g., Waco/ Killeen)
- Regional – stops at cities with population> 100,000
- Emerging – stops at cities with population> 50,000

Frequency of Service/ Headways

The assumed frequency of service for each of the levels of service was based on examples of similar systems already in place with comparable operating speeds as well as the frequency of available air flights between city pairs.

- Core Express – 20 trips in each direction daily (based on assumed 30 minute headways during peak hours 6-9am, and 4-7pm and 90 minute headways during off peak hours 9am-4pm and 7pm to 10pm)
- Regional – 12 trips per day in each direction daily (based on assumed 60 minute headways during peak hours 6-9am, and 4-7pm and 2 hour headways during off peak hours 9am-4pm and 7pm to 10pm)
- Emerging – 2 trains in each direction daily

Fares

Although a range of fares will be tested in the ridership model, initial assumed fares for the service level were estimated based on the comparable costs to fly or drive between the city pairs.

- Core Express – high fare = airfare, low fare = federal mileage rate*route distance
- Regional – high fare = federal mileage rate*route distance, low fare = fuel cost to drive
- Emerging – high fare = federal mileage rate*route distance, low fare = fuel cost to drive

The federal mileage rate used for the fare calculations was $0.555 at the time of this study, while the average price of fuel for the State of Texas was reported as by the American Automobile Association (AAA) as $3.394 per gallon for regular gasoline.

Level of Service Characteristics by Corridor

The criteria for each level of service as previously listed were utilized to create a matrix defining the base assumptions for service characteristics to be modeled in the Statewide Ridership Model for each of the city pairs as shown in Appendix A.

4.0 Cost Effectiveness Analysis

This section provides a summary of the assumptions made, methodology used and outcomes achieved in a preliminary analysis of cost effectiveness of the potential intercity passenger rail corridors. The following two main measures of cost effectiveness were used:

- Cost Recovery Ratio (Annual Revenue from Fare / Annual O&M Cost)
- Cost per hour of user benefit

First, specific measures of cost were developed for each corridor. The following measures of cost were used in the cost effectiveness analysis.

- Annual intercity passenger rail system O&M cost for each of the Build Scenarios
- Annualized total capital costs for each of the Build Scenarios developed by the project team.

The estimated capital costs include station costs, infrastructure costs, and equipment costs for each corridor.

Development of Cost Estimates

The methodology used to determine estimates of capital and operating and maintenance costs for each of the city-pair scenarios identified and analyzed in the Statewide Ridership Analysis is summarized in the following section and described in further detail in the technical memorandum included as Appendix B to this report. The probability distribution analysis was performed in order to address the uncertainty in estimates of capital and operating costs and provide a range of possible outcomes.

Cost estimates provided for each corridor were based solely on assumed general costs per mile for infrastructure as well as operating and maintenance requirements depending on the level of service, and did not account for specific corridor attributes. Rolling stock costs were based on an assumed type of technology and frequency of service for each level of service. The estimated costs will be further refined as the corridors are further advanced, should funding allow, to the stages of developing Service Development Plans, Preliminary Engineering, and NEPA documentation.

There were 64 city-pair/level-of service corridors identified through the previously described evaluation of city-pairs and associated levels of service for which single-point cost estimates were prepared. These city-pair/level-of-service corridors were analyzed assuming that each corridor was mutually exclusive. Table 12 lists the identified city-pairs along with the related levels-of-service analyzed.

Table 12: City-Pairs by Level-of-Service Analyzed

City-Pair		Level-of Service		
Terminus 1	Terminus 2	Core Express	Regional	Emerging
Dallas	San Antonio	X		
Dallas	Houston	X		
Fort Worth	Houston	X		
DFW/CentrePort	Houston	X		
Dallas	Austin	X		
Houston	San Antonio	X		
Austin	Houston	X		
Dallas	Oklahoma City	X		
Austin	San Antonio	X		
Fort Worth	College Station		X	X
Fort Worth	Baton Rouge		X	X
Houston	Killeen		X	X
Houston	Waco		X	X
Houston	Tyler		X	X
Beaumont	Brownsville		X	X
Oklahoma City	San Antonio		X	X
Houston	Longview		X	X
Houston	Little Rock		X	X
Beaumont	Laredo		X	X
Dallas	Laredo		X	X
Oklahoma City	Tyler		X	X
Longview	Oklahoma City		X	X
Longview	San Antonio		X	X
Killeen	Oklahoma City		X	X
Beaumont	McAllen		X	X
Fort Worth	Beaumont		X	X
Austin	Baton Rouge		X	X
Lubbock	Tyler		X	X
Fort Worth	Little Rock		X	X
Baton Rouge	San Antonio		X	X

City-Pair		Level-of Service		
Terminus 1	Terminus 2	Core Express	Regional	Emerging
Dallas	Albuquerque		X	X
College Station	San Antonio		X	X
Dallas	McAllen		X	X
El Paso	Austin		X	X
Albuquerque	El Paso		X	X
Fort Worth (via Midland-Odessa & San Angelo)	El Paso		X	
Dallas (via Midland-Odessa)	El Paso			X
Dallas (via San Angelo)	El Paso			X

The cost metrics forecasted within the probability distribution model were total corridor capital cost, annual corridor operating and maintenance costs, and total annualized corridor cost. The total corridor capital cost (capital cost) metrics were assembled from three cost components, each with their own levels of variability and uncertainty: 1) station cost, 2) infrastructure cost, and 3) equipment cost. The total annualized corridor cost was calculated using the total corridor capital cost annualized based on life expectancies for the various components of that cost and the annual operating and maintenance cost. The input assumptions for the individual metrics were estimated either as an annual amount or as a life of component amount that was annualized utilizing component life expectancies.

The 90-percent (P90) level of confidence reporting probability for the estimated costs were utilized in the cost effectiveness analysis. It should be noted that use of P90 as a decision criteria is a risk averse approach (whereas the use of P50 would be a risk neutral approach, and use of levels less than 50-percent would be risk seeking).

The cost and life expectancy input assumptions were selected at a cursory level of detail intended to be applied statewide for the various corridors due to the preliminary nature of the study. As the project(s) mature, the input assumptions should become divided into more specific assumptions as knowledge of the individual corridors increase.

Subject Matter Experts (SMEs) were utilized to estimate most-likely, low, and high values for each of the input assumptions utilized to exhibit uncertainty in the costs. These 3 data points were applied to a standard BetaPERT probability distribution. A BetaPERT probability distribution is a continuous distribution that describes a situation with a limited amount of data. The distribution works well with expert data. SMEs were also utilized to determine the correlation coefficients applied to the cost components to address the dependency of one variable assumption to a different variable assumption. The correlation coefficient values indicate how much of a change in one variable is explained by a change in another, such as: as the cost of the infrastructure increases, generally the O&M cost will increase also.

Key Cost Assumptions

The input assumptions for the model that have associated variability are shown in Tables 13 through 16.

Infrastructure

The infrastructure cost includes track elements, structures, signal systems, stations, ancillary facilities, and right-of-way. The costs for core express and regional service assume all new track construction, while emerging service would only require improvements to existing track to improve maximum allowable speeds and provide additional capacity. The cost per mile for emerging service may vary by corridor depending on the class of track and available capacity of the existing freight rail lines. This consolidated level of estimation ignores the terrain and environmental differences among city-pairs.

Table 13: Infrastructure Cost and Component Life Expectancy Assumptions

Assumption Description	Low Value	Most-Likely Value	High Value
Core Express - Infrastructure Cost Per Mile	$30,000,000	$50,000,000	$80,000,000
Regional - Infrastructure Cost Per Mile	$10,000,000	$15,000,000	$60,000,000
Emerging - Infrastructure Cost Per Mile	$5,000,000	$7,000,000	$30,000,000
Civil - Life Expectancy in Years	25	45	60
Structures - Life Expectancy in Years	50	100	125
System - Life Expectancy in Years	15	30	50
Facilities - Life Expectancy in Years	15	50	75
Crossings - Life Expectancy in Years	5	15	30
Electrification - Life Expectancy in Years	15	30	50

Stations

The estimated station costs vary depending on the assumed size of each station, which was estimated based on the ridership estimated to be served at each station.

Table 14: Station Cost and Life Expectancy Assumptions

Assumption Description	Low Value	Most-Likely Value	High Value
"Hub" Station Cost	$106,000,000	$120,000,000	$135,000,000
"Major" Station Cost	$50,000,000	$60,000,000	$66,000,000
"Intermediate" Station Cost	$20,000,000	$30,000,000	$30,000,000
"Minor" Station Cost	$5,000,000	$5,000,000	$15,000,000
"Hub" Station - Life Expectancy in Years	50	75	75
"Major" Station - Life Expectancy in Years	40	75	75
"Intermediate" Station - Life Expectancy in Years	30	75	75
"Minor" Station - Life Expectancy in Years	20	75	75

Rolling Stock (Equipment)

The estimated costs for rolling stock are based on acquiring new equipment with a total purchase of 30 or less trainsets.

Table 15: Train Set Cost and Life Expectancy Assumptions

Assumption Description	Low Value	Most-Likely Value	High Value
Core Express - Cost per Train Set	$41,000,000	$45,000,000	$51,000,000
Regional - Cost per Train Set	$35,000,000	$38,000,000	$41,000,000
Emerging - Cost per Train Set	$25,000,000	$30,000,000	$35,000,000
Core Express Train Set - Life Expectancy in Years	25	25	30
Regional Train Set - Life Expectancy in Years	25	25	30
Emerging Train Set - Life Expectancy in Years	25	25	30

Operating and Maintenance

The operating and maintenance costs include operator profit, administration and management, station costs, sales and marketing, insurance liability, track and ROW maintenance, energy and fuel, equipment maintenance, on-board service crews, and train crews. Several components of the operating and maintenance costs vary depending on the type of equipment technology utilized, such as the examples listed below.

- 79-mph conventional diesel
- 110-mph high-speed diesel
- 150-mph electric locomotive-hauled high-speed rail

- 220-mph electric multiple-unit (self-propelled) high-speed rail
- 125-mph Maglev (linear induction motor)
- 300-mph Transrapid Maglev (linear synchronous motor)

Although the type of technology for each corridor is not known at this stage, unit costs per train mile traveled for each level of service were estimated based on reported O&M costs for existing and planned comparable services. The train miles were estimated based on the calculated route miles and the frequency of trains per day for each level of service.

Table 16: Operating & Maintenance Cost Assumptions

Assumption Description	Low Value	Most-Likely Value	High Value
Core Express - O&M Cost per Train Mile Traveled	$25	$40	$65
Regional - O&M Cost per Train Mile Traveled	$30	$45	$70
Emerging - O&M Cost per Train Mile Traveled	$30	$50	$85

Cost Probability Analysis Results

Table 17 presents the total corridor capital cost for each of the 64 city-pair/level-of-service corridors. The median value for each corridor represents the amount where half of the Monte Carlo Simulation iterations produced resulted in values less than the median value and half of the iterations produced resulted in values greater than the median. The P75 value is larger than 75-percent of the iterations produced and the P90 value is larger than 90-percent of the iterations produced. The P90 value for the first City-Pair/Level-of-Service corridor listed can be further communicated by the following statement: “There is a 90-percent probability that the total corridor capital cost will not be greater than $20.4 billion for the Dallas-San Antonio core express corridor.”

Table 17: Total Estimated Corridor Capital Cost (Billions of Dollars)

City-Pair			Total Corridor Capital Cost		
Terminus 1	Terminus 2	Level-of Service	Median ($B)	P75 ($B)	P90 ($B)
Dallas	San Antonio	Core Express	$16.3	$18.5	$20.4
Dallas	Houston	Core Express	$14.6	$16.6	$18.3
Fort Worth	Houston	Core Express	$16.3	$18.5	$20.4
DFW/CentrePort	Houston	Core Express	$15.4	$17.5	$19.2
Dallas	Austin	Core Express	$12.1	$13.7	$15.2
Houston	San Antonio	Core Express	$10.7	$12.1	$13.3
Austin	Houston	Core Express	$8.8	$10.0	$11.0

City-Pair			Total Corridor Capital Cost		
Terminus 1	Terminus 2	Level-of Service	Median ($B)	P75 ($B)	P90 ($B)
Dallas	Oklahoma City	Core Express	$12.4	$14.1	$15.5
Austin	San Antonio	Core Express	$4.3	$4.9	$5.4
Fort Worth	College Station	Regional	$4.2	$5.5	$6.8
Fort Worth	Baton Rouge	Regional	$9.1	$11.9	$14.8
Houston	Killeen	Regional	$4.1	$5.3	$6.6
Houston	Waco	Regional	$3.9	$5.1	$6.3
Houston	Tyler	Regional	$4.3	$5.6	$6.9
Beaumont	Brownsville	Regional	$10.0	$13.0	$16.1
Oklahoma City	San Antonio	Regional	$10.6	$13.9	$17.2
Houston	Longview	Regional	$4.3	$5.6	$6.9
Houston	Little Rock	Regional	$9.6	$12.6	$15.6
Beaumont	Laredo	Regional	$9.3	$12.2	$15.1
Dallas	Laredo	Regional	$10.3	$13.5	$16.7
Oklahoma City	Tyler	Regional	$7.1	$9.2	$11.5
Longview	Oklahoma City	Regional	$7.4	$9.6	$12.0
Longview	San Antonio	Regional	$8.4	$10.9	$13.5
Killeen	Oklahoma City	Regional	$7.6	$10.0	$12.4
Beaumont	McAllen	Regional	$10.0	$13.1	$16.2
Fort Worth	Beaumont	Regional	$7.7	$10.0	$12.4
Austin	Baton Rouge	Regional	$9.0	$11.8	$14.6
Lubbock	Tyler	Regional	$9.5	$12.4	$15.3
Fort Worth	Little Rock	Regional	$8.2	$10.7	$13.4
Baton Rouge	San Antonio	Regional	$10.3	$13.5	$16.7
Dallas	Albuquerque	Regional	$13.7	$17.9	$22.3
College Station	San Antonio	Regional	$3.5	$4.6	$5.7
Dallas	McAllen	Regional	$13.6	$17.8	$22.1
Fort Worth (via Midland-Odessa & San Angelo)	El Paso	Regional	$13.5	$17.7	$21.9
El Paso	Austin	Regional	$13.7	$18.0	$22.3
Albuquerque	El Paso	Regional	$5.1	$6.7	$8.3
Fort Worth	College Station	Emerging	$2.0	$2.7	$3.4

City-Pair			Total Corridor Capital Cost		
Terminus 1	Terminus 2	Level-of Service	Median ($B)	P75 ($B)	P90 ($B)
Fort Worth	Baton Rouge	Emerging	$4.5	$5.9	$7.4
Houston	Killeen	Emerging	$2.1	$2.8	$3.5
Houston	Waco	Emerging	$1.9	$2.5	$3.1
Houston	Tyler	Emerging	$2.8	$3.7	$4.6
Beaumont	Brownsville	Emerging	$4.9	$6.5	$8.1
Oklahoma City	San Antonio	Emerging	$5.2	$6.9	$8.7
Houston	Longview	Emerging	$2.3	$3.1	$3.8
Houston	Little Rock	Emerging	$4.7	$6.2	$7.8
Beaumont	Laredo	Emerging	$4.6	$6.1	$7.6
Dallas	Laredo	Emerging	$5.1	$6.7	$8.4
Oklahoma City	Tyler	Emerging	$3.5	$4.7	$5.9
Longview	Oklahoma City	Emerging	$3.6	$4.7	$6.0
Longview	San Antonio	Emerging	$3.4	$4.5	$5.6
Killeen	Oklahoma City	Emerging	$3.8	$5.0	$6.2
Beaumont	McAllen	Emerging	$5.2	$6.9	$8.6
Fort Worth	Beaumont	Emerging	$3.6	$4.7	$5.9
Austin	Baton Rouge	Emerging	$5.0	$6.5	$8.2
Lubbock	Tyler	Emerging	$4.7	$6.2	$7.8
Fort Worth	Little Rock	Emerging	$3.9	$5.2	$6.5
Baton Rouge	San Antonio	Emerging	$5.0	$6.6	$8.3
Dallas	Albuquerque	Emerging	$7.4	$9.7	$12.2
College Station	San Antonio	Emerging	$1.9	$2.5	$3.2
Dallas	McAllen	Emerging	$6.7	$8.8	$11.1
Dallas (via Midland-Odessa)	El Paso	Emerging	$6.4	$8.5	$10.7
Dallas (via San Angelo)	El Paso	Emerging	$7.3	$9.6	$12.1
El Paso	Austin	Emerging	$6.9	$9.1	$11.4
Albuquerque	El Paso	Emerging	$2.5	$3.4	$4.2

Table 18 presents the annual corridor operating and maintenance costs for each of the 64 city-pair/level-of-service alternatives.

Table 18: Annual Corridor Operating & Maintenance Costs (Millions of Dollars)

City-Pair			Annual Corridor O&M Costs		
Terminus 1	Terminus 2	Level-of Service	Median ($M)	P75 ($M)	P90 ($M)
Dallas	San Antonio	Core Express	$185	$211	$234
Dallas	Houston	Core Express	$166	$189	$209
Fort Worth	Houston	Core Express	$185	$211	$234
DFW/CentrePort	Houston	Core Express	$175	$199	$220
Dallas	Austin	Core Express	$137	$156	$173
Houston	San Antonio	Core Express	$120	$138	$152
Austin	Houston	Core Express	$99	$113	$125
Dallas	Oklahoma City	Core Express	$140	$160	$177
Austin	San Antonio	Core Express	$48	$55	$61
Fort Worth	College Station	Regional	$79	$89	$97
Fort Worth	Baton Rouge	Regional	$174	$196	$215
Houston	Killeen	Regional	$76	$86	$94
Houston	Waco	Regional	$73	$82	$91
Houston	Tyler	Regional	$80	$90	$99
Beaumont	Brownsville	Regional	$191	$215	$236
Oklahoma City	San Antonio	Regional	$205	$231	$253
Houston	Longview	Regional	$81	$91	$100
Houston	Little Rock	Regional	$184	$208	$228
Beaumont	Laredo	Regional	$178	$201	$220
Dallas	Laredo	Regional	$199	$223	$245
Oklahoma City	Tyler	Regional	$135	$152	$166
Longview	Oklahoma City	Regional	$141	$159	$174
Longview	San Antonio	Regional	$161	$181	$198
Killeen	Oklahoma City	Regional	$146	$165	$180
Beaumont	McAllen	Regional	$192	$216	$237
Fort Worth	Beaumont	Regional	$147	$165	$181
Austin	Baton Rouge	Regional	$172	$195	$213
Lubbock	Tyler	Regional	$182	$204	$224

City-Pair			Annual Corridor O&M Costs		
Terminus 1	Terminus 2	Level-of Service	Median ($M)	P75 ($M)	P90 ($M)
Fort Worth	Little Rock	Regional	$158	$178	$195
Baton Rouge	San Antonio	Regional	$198	$222	$244
Dallas	Albuquerque	Regional	$264	$298	$326
College Station	San Antonio	Regional	$66	$75	$82
Dallas	McAllen	Regional	$263	$296	$324
Fort Worth (via Midland-Odessa & San Angelo)	El Paso	Regional	$261	$295	$322
El Paso	Austin	Regional	$266	$299	$328
Albuquerque	El Paso	Regional	$98	$110	$120
Fort Worth	College Station	Emerging	$16	$18	$20
Fort Worth	Baton Rouge	Emerging	$34	$39	$44
Houston	Killeen	Emerging	$16	$18	$20
Houston	Waco	Emerging	$14	$17	$19
Houston	Tyler	Emerging	$21	$24	$27
Beaumont	Brownsville	Emerging	$38	$43	$48
Oklahoma City	San Antonio	Emerging	$40	$47	$52
Houston	Longview	Emerging	$18	$20	$23
Houston	Little Rock	Emerging	$36	$42	$46
Beaumont	Laredo	Emerging	$35	$40	$45
Dallas	Laredo	Emerging	$39	$45	$50
Oklahoma City	Tyler	Emerging	$27	$32	$35
Longview	Oklahoma City	Emerging	$28	$32	$35
Longview	San Antonio	Emerging	$26	$30	$33
Killeen	Oklahoma City	Emerging	$29	$33	$37
Beaumont	McAllen	Emerging	$40	$46	$51
Fort Worth	Beaumont	Emerging	$28	$32	$35
Austin	Baton Rouge	Emerging	$38	$44	$48
Lubbock	Tyler	Emerging	$36	$42	$46
Fort Worth	Little Rock	Emerging	$30	$35	$38
Baton Rouge	San Antonio	Emerging	$38	$44	$49
Dallas	Albuquerque	Emerging	$56	$65	$72

City-Pair			Annual Corridor O&M Costs		
Terminus 1	Terminus 2	Level-of Service	Median ($M)	P75 ($M)	P90 ($M)
College Station	San Antonio	Emerging	$15	$17	$19
Dallas	McAllen	Emerging	$51	$59	$66
Dallas (via Midland-Odessa)	El Paso	Emerging	$49	$56	$62
Dallas (via San Angelo)	El Paso	Emerging	$55	$64	$71
El Paso	Austin	Emerging	$53	$61	$67
Albuquerque	El Paso	Emerging	$19	$22	$25

Appendix B contains details for each of the 64 city-pair/level-of-service alternatives for the total corridor capital cost metric and the annual corridor operating & maintenance costs metric as well as additional detail regarding the methodology utilized for the probability analysis.

Corridor Cost Effectiveness Analysis Results

Once the costs for each corridor were developed, the Statewide Analysis Model Version 2.5 (SAM-V2.5) model was used to analyze the forecasted 2035 intercity passenger rail ridership at three different levels of service: core express, regional, and emerging. The corridors were ranked on likelihood of potential intercity passenger rail ridership based on terminal population, distance between MSAs, and airline flight frequency as previously described. The corridors were run from the highest ranking to the lowest ranking until the corridors no longer reached the specified cost recovery thresholds for each service level. The cost recovery threshold is represented by the amount of operating and maintenance costs recovered by the fare box revenue (100% for core express, 75% for regional, 50% for emerging). The fare box revenue was calculated as the total number of new riders per year multiplied by the assumed passenger rail fare to calculate total fares collected. The total fare box receipts were discounted to net present value in 2010 year dollars and then compared to the cost to determine if the corridor met the cost recovery threshold.

If the corridors met the cost recovery threshold, then the Federal Transit Administration's (FTA) Summit Software was used in quantifying the user benefits for the different corridors. The transportation system user benefits is representative of total system expenditure savings in hours, which is the travel time savings between the build scenario (each potential intercity passenger rail corridor) and the no build scenario (no new intercity passenger rail corridors). The weekday user benefits, or expenditure savings in hours, were then multiplied by an annual factor to establish the annual estimate of total system user benefits in hours per year. The benefits analyzed included the following effectiveness inputs:

- Transportation System User Benefits (TSUB) measured in hours per year based on Summit output
- Total additional intercity passenger rail ridership measured in new riders per year based on SAM-V2.5 output

After all of the input values for each corridor alternative were calculated, the cost effectiveness of each alternative was analyzed. The cost effectiveness for each corridor was evaluated based on the cost per hour of user benefit and the cost recovery ratio. The cost and benefit input values developed, as well as the cost effectiveness output is summarized for each service level in Tables 19 through 21.

Daily ridership (typical weekday) was forecast for 2035 for the proposed high speed rail service with the SAM-V2.5. An additional factor was applied to these results to derive weekend ridership[4]. The forecasted ridership estimates provided in this study do not include induced ridership.

<u>Core Express Corridors</u>

The results from the cost effectiveness analysis of the core express corridors are shown in Table 19. Each core express corridor had varying levels of cost (including capital and operating and maintenance), forecasted 2035 intercity passenger rail ridership, revenue in 2010 dollars, total system user benefit in hours, and cost per hour of user benefit in 2010 dollars. The cost per hour of user benefit can be used as a comparative measure between the corridors to determine which corridors are the most cost effective. Lower values indicate more cost effective corridors.

The Austin-Houston core express corridor had the highest level of cost effectiveness, or cost per hour of user benefit. Not only did the Austin-Houston corridor have the highest ridership and second highest revenue, it also had the lowest cost per hour of user benefit. The corridor with the second highest cost effectiveness, or cost per hour of user benefit, was the Houston-San Antonio corridor. The Houston-San Antonio corridor had the third lowest cost, third highest ridership, fifth highest revenue, and fifth highest total system user benefits.

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[4] The 2009 National Household Transportation Survey (NHTS) provides the basis for the calculation of weekend ridership that is paired with the weekday ridership forecast with the Statewide Analysis Model (SAM). The NHTS allowed for an examination of Weekday (Mon-Thurs) long distance travel (150 miles or more) as compared with weekend (Fri-Sun) long distance travel.

The relationships between the benefit, cost, and cost effectiveness variables demonstrate that the cost effectiveness is a comprehensive effectiveness measure for each corridor.

Table 19: Core Express Service Cost Effectiveness Results

Origin	Destination	2035 Annual Ridership[5]	Total Capital Cost	Annual O&M Cost	Annual Fare Box Revenue	Cost Recovery Ratio	Annual Total System User Benefits (hours)	Cost per Hour of User Benefit
Austin	Houston	5.5M	$11.0B	$125M	$506M	4.05	2.4M	$150
Houston	San Antonio	4.2M	$13.3B	$152M	$460M	3.03	2.3M	$190
Dallas	Houston	3.6M	$18.3B	$209M	$448M	2.14	2.3M	$250
Dallas	Austin	4.0M	$15.2B	$273M	$373M	2.16	1.9M	$260
Fort Worth	Houston	3.8M	$20.4B	$234M	$479M	2.05	2.4M	$270
Dallas	San Antonio	4.9M	$20.4B	$234M	$522M	2.23	2.4M	$280
Dallas	Oklahoma City	2.4M	$15.5B	$177M	$275M	1.55	1.4M	$350
DFW/ Airport	Houston	2.9M	$19.2B	$220M	$354M	1.61	1.7M	$360
Austin	San Antonio	0.27M	$5.4B	$61M	$11M	0.18	51K	$3,390

Regional Corridors

The results from the cost effectiveness analysis of the regional service corridors are shown in Table 20. Similar to the core express corridors, each regional corridor had varying levels of cost (including capital and operating and maintenance), 2035 ridership, revenue in 2010 dollars, total system user benefit in hours, and cost per hour of user benefit in 2010 dollars. The cost per hour of user benefit can be used as a comparative measure between the corridors to determine which corridor is the most cost effective.

The Waco-Houston regional corridor had the highest level of cost effectiveness, or cost per hour of user benefit. Not only did the Waco-Houston corridor have the highest ridership and

[5] Ridership estimates are reported in ranges following the probability analysis section to account for uncertainty.

highest revenue, it also had the lowest cost and lowest cost per hour of user benefit. The regional corridor with the second highest cost effectiveness, or cost per hour of user benefit, was the Fort Worth-College Station corridor. The Fort Worth-College Station corridor had the third lowest cost, third highest ridership, third highest revenue, and highest total system user benefits. The relationships between the benefit, cost, and cost effectiveness variables demonstrate that the cost effectiveness is a comprehensive effectiveness measure for each corridor.

Table 20: Regional Service Cost Effectiveness Results

Origin	Destination	2035 Annual Ridership[6]	Total Capital Cost	Annual O&M Cost	Annual Fare Box Revenue	Cost Recovery Ratio	Annual Total System User Benefits (hours)	Cost per Hour of User Benefit
Waco	Houston	1.4M	$6.3B	$91M	$105M	1.15	400K	$350
Fort Worth	College Station	0.81M	$6.8B	$97M	$75M	0.77	450K	$550
Houston	Killeen	0.81M	$6.6B	$94M	$55M	0.59	320K	$750
Tyler	Houston	0.54M	$6.9B	$99M	$59M	0.60	210K	$1,190
Fort Worth	Baton Rouge	1.2M	$14.8B	$215M	$102M	0.47	300K	$1,800

Emerging Corridors

The results from the cost effectiveness analysis of the emerging service corridors are shown in Table 21. Similar to the core express and regional corridors, each emerging corridor had varying levels of cost (including capital and operating and maintenance), 2035 ridership, revenue in 2010 dollars, total system user benefit in hours, and cost per hour of user benefit in 2010 dollars. The cost per hour of user benefit can be used as a comparative measure between the corridors to determine which corridor is the most cost effective.

The Waco-Houston emerging corridor also had the highest level of cost effectiveness, or cost per hour of user benefit. The Waco-Houston corridor had the lowest cost, highest ridership, lowest revenue, highest total system user benefits, as well as the lowest cost per hour of user benefit. The emerging corridor with the second highest cost effectiveness, or cost per hour of user benefit, was the Tyler-Houston corridor. The Tyler-Houston corridor had the third highest cost, highest ridership, second highest revenue, and third highest total system user benefits. The relationships between the benefit, cost, and cost effectiveness variables demonstrate that the cost effectiveness is a comprehensive effectiveness measure for each corridor.

[6] Ridership estimates and are reported in ranges following the probability analysis section to account for uncertainty.

Table 21: Emerging Service Cost Effectiveness Results

Origin	Destination	2035 Annual Ridership[7]	Total Capital Cost	Annual O&M Cost	Annual Fare Box Revenue	Cost Recovery Ratio	Annual Total System User Benefits (hours)	Cost per Hour of User Benefit
Waco	Houston	0.38M	$3.1B	$19M	$22M	1.16	200K	$760
Tyler	Houston	0.38M	$4.6B	$27M	$15M	0.56	150K	$880
Killeen	Houston	0.22M	$3.5B	$20M	$12M	0.60	120K	$890
Fort Worth	Baton Rouge	0.32M	$7.4B	$44M	$18M	0.41	150K	$2,170
Fort Worth	College Station	.12M	$3.4B	$20M	$11M	0.55	70K	$2,370
Beaumont	Brownsville	0.24M	$8.1B	$48M	$14M	0.29	70K	$3,430

[7] Ridership estimates are reported in ranges following the probability analysis section to account for uncertainty.

5.0 System Optimization Analysis

A system optimization analysis was performed to evaluate the impact of combining the high-performing individual corridors into a core system and the impact of incrementally adding corridors to that system. The various system combinations were evaluated based to determine the impact of the system to the individual corridor ridership forecasts and annual revenue from fares as well as the impact to the overall system cost recovery ratio, cost effectiveness, and user benefits of adding additional corridors to the system.

Although not evaluated in this study, considerations for connecting multiple corridors that may be owned and operated by different parties should be coordinated in the future. System integration considerations are summarized below:

- Infrastructure
  - Connecting corridors should have common hub stations connecting them.
  - Trains should arrive at a common platform.
  - Different equipment types can be used with different top speeds and operating characteristics. However equipment must be standardized with regard to platform height and length requirements.
  - Cross-platform boarding may be required.
- Operations
  - Schedules must be consistent with regard to frequencies.
  - Train arrival and departure times at stations shared by multiple routes/ services should be coordinated to allow passengers to move across the platform from the arriving train to the departing train seamlessly.
  - This will require integrated dispatching and communications systems to address any operating and schedule issues that develop.
  - Ticketing and revenue management systems should be coordinated to allow through-ticketing regardless of which operator originates the trip. This may require some kind of integration of ticketing and reservations systems technology.
  - Baggage handling may present a challenge. Checked baggage may not be possible.
- Operating and maintenance expenses
  - Agreements for shared track and stations may be required.

The following section provides a comprehensive summary of the methodology, assumptions, and outcomes of the system optimization analysis, while detailed tables and figures showing the results of each system alternative analyzed are included in Appendix D.

Analysis Approach / Methodology

The SAM-V2.5 travel demand model was used to measure and compare the travel utility and cost effectiveness of seven candidate intercity passenger rail systems. Utility is the measure of traveler's perception of how easy a mode is to access and how useful it is to them in achieving their travel objective. In the SAM-V2.5 mode choice model utility is measured in terms of a combination of variables related to travel cost, travel time, convenience and reliability. The candidate systems were created by combining high-performing individual corridors based on professional judgment and the rankings from the travel market and cost effectiveness analyses.

Core System

The SAM-V2.5 was run on a Core System consisting of three core express corridors. The Core System consisted of the following corridors:

- Dallas to San Antonio Core Express
- Fort Worth to Houston Core Express
- Austin to Houston Core Express

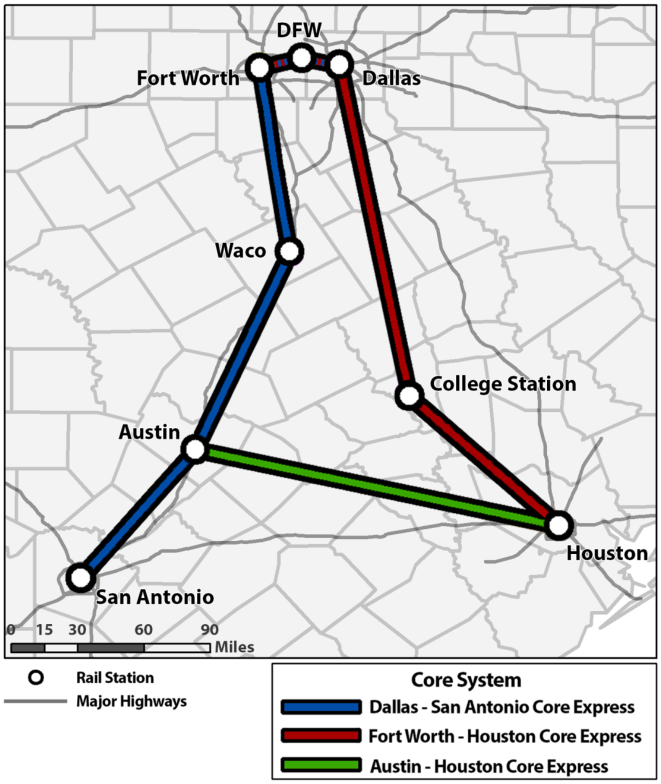

Figure 6: Core System Route Concept

After the Core System was defined, a SAM-V2.5 model run was performed using the service parameters (fare, average travel speed, etc.) of the Core System as previously defined in the Level of Service Assumptions section of this report. The performance of the Core System was analyzed using several key performance indicators, including revenue and cost effectiveness.

The first measure of cost effectiveness was reported in terms of unit cost, or dollars per hour of total system user benefit. This measure aligns with the methodology used by the Federal Transit Administration (FTA) to calculate cost effectiveness for all New Starts projects. This measure was calculated by dividing the total annualized costs of the system by the total system user benefits (see formula below).

$$\boldsymbol{Cost\ Per\ Hour\ of\ User\ Benefit} = \frac{(Annualized\ Capital\ Cost) + (Total\ Systemwide\ Annual\ Operating\ \&\ Maintenance\ Cost)}{Annual\ Total\ System\ User\ Benefits}$$

The second measure of cost effectiveness, Cost Recovery Ratio, was reported as the ratio of operating and maintenance costs recovered by the fare box revenue, which was based on high speed intercity passenger rail system riders per year. This ratio was developed using the formula below.

$$\boldsymbol{Cost\ Recovery\ Ratio} = \frac{Annual\ Operating\ and\ Maintenance\ Costs}{Annual\ Fare\ Box\ Revenue}$$

Total revenue was determined by multiplying the total number of new riders per year by the intercity passenger rail fare. The total fare box receipts were discounted to Net Present Value (NPV) in the year 2010.

System Expansion

After the Core System was run, additional corridors were added iteratively to the Core System to create new candidate systems. The additional corridors were selected based on professional judgment and the rankings from the travel market and cost effectiveness analyses. In situations where the additional corridors overlapped the service of existing corridors, the route with the higher level of service was kept in order to avoid duplication of service. The additional corridors provided connectivity between new city pairs not included in the Core System, expanding the intercity passenger rail system market. The corridors that were incrementally added to the Core System include, in sequential order:

- San Antonio to Houston Core Express
- Oklahoma City to Dallas Core Express
- Waco to Houston (via College Station) Regional
- Killeen to Houston (via College Station) Regional
- Tyler to Houston Emerging
- Fort Worth to Baton Rouge Regional

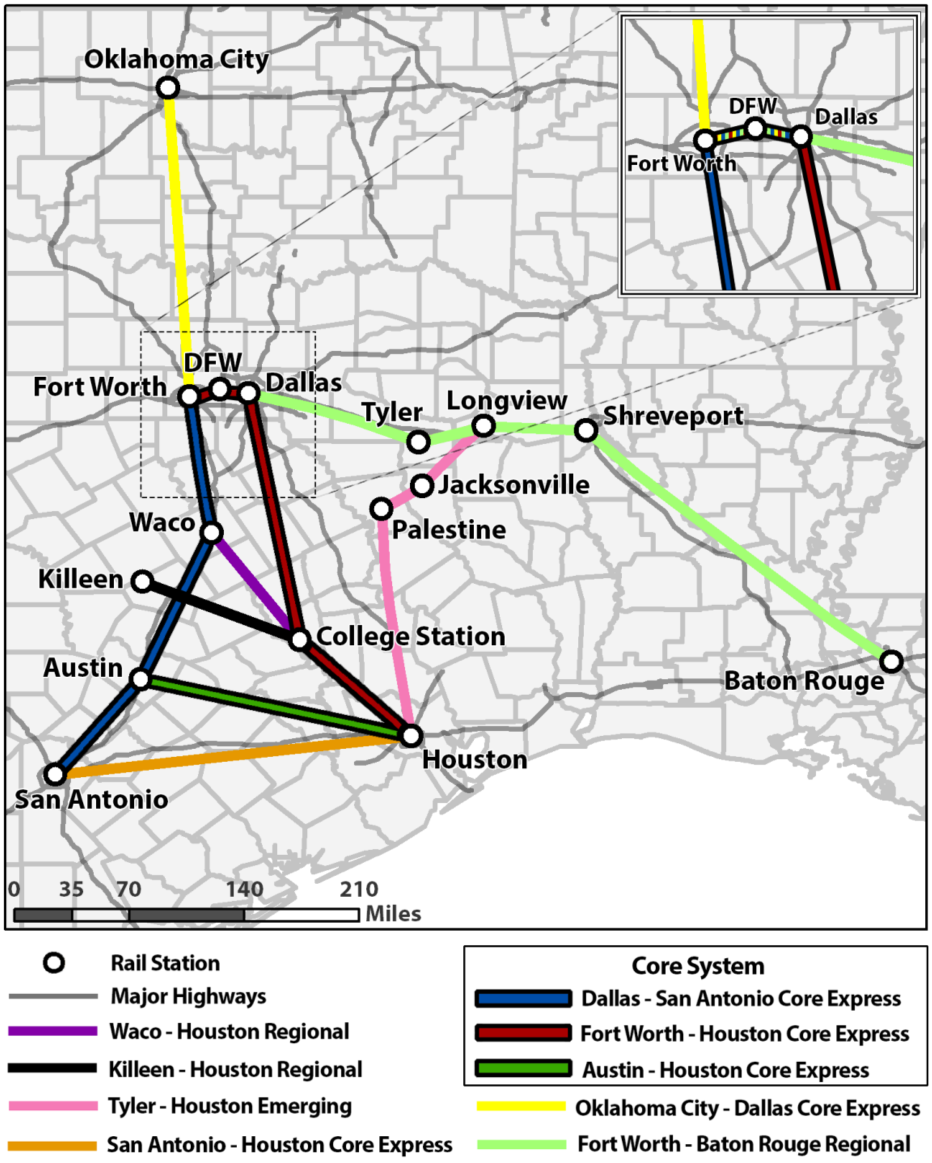

Figure 7: Expanded System Route Concept

Results

After each of the new corridors was added, the performance of the new system was compared to the performance of the Core System in terms of ridership and travel utility. A system performance summary, which includes total annualized costs, 2035 ridership, fare box revenue, and cost effectiveness of the seven intercity passenger rail systems, is presented in Table 25.

Daily ridership (typical weekday) was forecast for 2035 for the proposed high speed rail service for the Core System with the SAM-V2.5. An additional factor was applied to these results to derive weekend ridership[8]. Table 22 depicts 2035 daily and annual ridership for the Core System.

Table 22: Core System 2035 Ridership

Period	Weekday-Daily (Mon. – Thurs.)	Annual Weekday (Mon. – Thurs.)	Weekend-Daily (Fri. – Sun.)	Annual Weekend (Fri. – Sun.)	Total 2035 Annual Ridership	Annual Average Daily
Dallas-San Antonio Ridership	10,747	2,235,352	22,781	3,576,563	5,811,915	15,923
Fort Worth-Houston Ridership	6,244	1,298,801	13,236	2,078,082	3,376,883	9,252
Austin-Houston Ridership	11,559	2,404,308	24,503	3,846,893	6,251,201	17,127
Systemwide Total	**28,550**	**5,938,461**	**60,519**	**9,501,538**	**15,439,999**	**42,301**

Figure 8 on the next page shows 2035 daily weekday ridership on each segment of each route in the Core System, along with passenger boardings (on) and alightings (off) at each station. The colored arrows represent transfers made by passengers to other routes (minimum 10 passengers).

[8] The 2009 National Household Transportation Survey (NHTS) provides the basis for the calculation of weekend ridership that is paired with the weekday ridership forecast with the Statewide Analysis Model (SAM). The NHTS allowed for an examination of Weekday (Mon-Thurs) long distance travel (150 miles or more) as compared with weekend (Fri-Sun) long distance travel.

As shown in Figure 8, there were negligible transfers between the Dallas/ Fort Worth to Houston and the Dallas/ Fort Worth to San Antonio corridors. This is due to the nature of the geography for those two corridors, which essentially form the sides of a triangle. For example, the cost and trip time required to get between Houston and Waco would not be competitive via transfer between the two core express routes (going through Dallas/ Fort Worth) as compared to either driving or flying directly between the two cities. As a result, there was little system effect to the individual corridor ridership of including these two corridors together in a system. However, the ridership was increased by combining the Austin to Houston and Dallas/ Fort Worth to San Antonio corridors in a system, as there were transfers between those two routes. In conclusion, a “triangle system” causes little increase to corridor ridership forecasts, while a “T” system would experience greater transfers and resulting increases to individual corridor ridership forecasts.

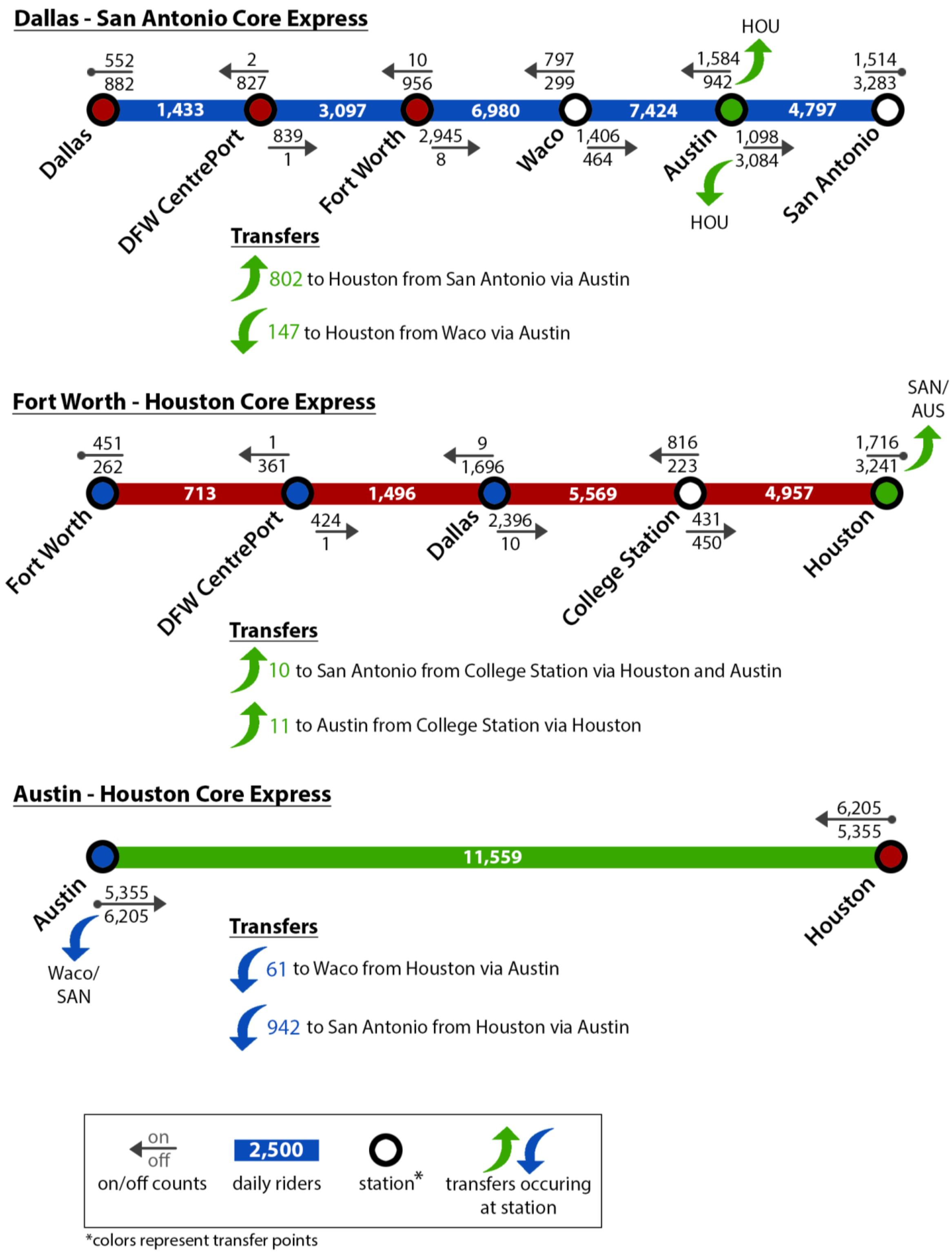

Figure 8: Core System Ridership by Segment

Core System Performance Measures

Performance measures, including Total Annual Revenue, Cost Recovery Ratio, and Cost per Hour of User Benefit, were calculated in order to evaluate the performance of the Core System as presented in Table 23 below.

Table 23: Core System Performance Measures

Performance Measure	Annual Fare Revenue	2035 Annual Ridership
System Total	**$1.6B**	**15.4M**
Total Revenue: Dallas – San Antonio Core Express	$560M	5.8M
Total Revenue: Fort Worth – Houston Core Express	$450M	3.4M
Total Revenue: Austin – Houston Core Express	$570M	6.2M
Cost Recovery Ratio	**2.80**	
Cost per Hour of User Benefit	**$195**	

Using the same methodology used for the Core System, performance measures were calculated for each corridor in System 7 (fully expanded system with all corridors included as shown in Figure 9). Performance Measures for the System 7 are presented in Table 24.

Table 24: System 7 Performance Measures

Performance Measure	Annual Fare Revenue	2035 Annual Ridership
System Total	**$2.2B**	**20.9M**
Total Revenue: Dallas – San Antonio Core Express	$520M	4.8M
Total Revenue: Fort Worth – Houston Core Express	$450M	3.5M
Total Revenue: Austin – Houston Core Express	$420M	4.5M
Total Revenue: San Antonio – Houston Core Express	$420M	3.8M
Total Revenue: Oklahoma City – Dallas Core Express	$280M	2.3M
Total Revenue: Waco – Houston Regional Rail	$20M	0.4M
Total Revenue: Killeen – Houston Regional Rail	$6.7M	0.1M
Total Revenue: Tyler – Houston Emerging Rail	$11M	0.2M
Total Revenue: Fort Worth – Baton Rouge Regional	$100M	1.3M
Cost Recovery Ratio	**2.15**	
Cost per Hour of User Benefit	**$336**	

Figure 9: System 7 Ridership by Route Segment

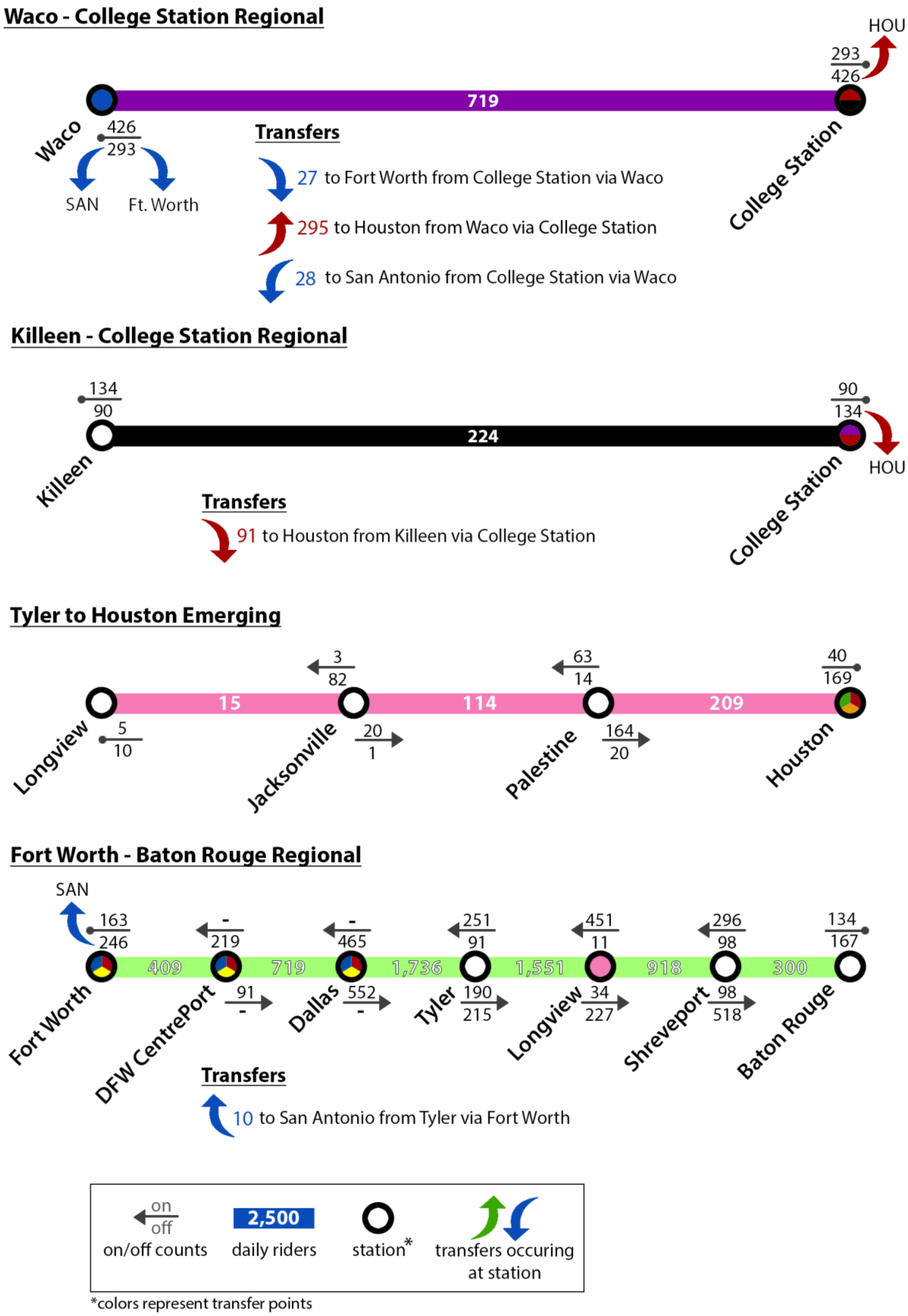

Figure 9 (continued): System 7 Ridership by Route Segment

The system performance summary, which includes total annualized costs, 2035 ridership, fare box revenue, and cost effectiveness of the seven intercity passenger rail systems, is presented in Table 25.

Table 25: Systems Performance Summary

System	Annual O&M Cost	2035 Annual Ridership	Annual Fare Box Revenue	Annual Total System User Benefits	Cost Recovery Ratio	Cost per Hour of User Benefit
Core	$567M	15.4M	$1.6B	8.2M	2.80	$195
2	$719M	16.8M	$1.8B	8.1M	2.54	$250
3	$871M	19.1M	$2.1B	9.6M	2.41	$256
4	$917M	19.4M	$2.1B	9.6M	2.29	$267
5	$967M	19.5M	$2.1B	9.6M	2.18	$280
6	$994M	19.8M	$2.1B	9.7M	2.13	$291
7	$1,034M	20.9M	$2.2B	10M	2.15	$336

Although individual results were not shown in this report, model runs were performed for system alternatives 2 through 6 based on incrementally adding the corridors one at a time to the Core System until all corridors shown in Figure 9 were included as shown in the System 7 results above. Results for the other system alternatives are shown in the System Optimization Technical Memorandum shown in Appendix D.

Overall, the results of this analysis show that while each additional corridor had its own independent utility, the addition of new corridors to the system caused the Cost Recovery Ratio to decrease and the Cost per Hour of User Benefit to increase due to higher system costs and somewhat redundant services. For example, the significant decrease in forecasted ridership and revenue along the Austin to Houston corridor, resulting from adding the San Antonio to Houston corridor, and the overall significant reduction in the system cost recovery ratio implies that the two core express corridors are somewhat redundant. Similar results were found for the Waco to Houston and the Killeen to Houston corridors. The lone exception to this rule was System 7, which saw a slight decrease in Cost Recovery Ratio compared to the previous system, though this is due mainly to the fact that much of the cost associated with the Fort Worth to Baton Rouge corridor added in System 7 was already accounted for in System 6 due to overlapping corridors.

6.0 Ridership Probability Analysis

An uncertainty analysis was conducted as part of the Statewide Ridership Analysis in order to provide a range of estimated annual riders for all of the corridors tested in the ridership model, rather than single point estimates. This was done to account for the variability in forecasted ridership that may be caused by the application of assumptions statewide to the various corridors as well as other corridor-specific unknown conditions. The analysis provides ridership distributions that can be utilized to estimate a range for the forecasted ridership depending on key input variables such as fare and travel speed/ trip time. This uncertainty analysis consisted of the following four components:

1. Determination of sample corridors and input variables to be tested in the ridership model for the uncertainty analysis
2. Production of ridership model runs estimating the total annual riders for each sample corridor based on variation of the input variables
3. Evaluation of ridership model outputs (total annual riders) and application of a probability distribution for each sample corridor
4. Application of sample corridor probability distributions to remaining corridors

The following technical memorandum describes the methodology used in each of the four components of the uncertainty analysis listed above, as well as the resulting distributions for the forecasted total annual riders for each corridor tested in the Statewide Ridership model, as previously described in the technical memorandum for the cost effectiveness analysis.

Approach and Key Assumptions

The first step of the uncertainty analysis was to determine which corridors would be used as the sample corridors for testing in the ridership model, which variables would be used, and how they would be varied to determine the impact on forecasted annual ridership.

The corridor with the highest forecasted ridership within each service level, based on the results of the cost effectiveness analysis, was utilized as the sample corridor for the purposes of the uncertainty analysis. The sample corridors are listed in Table 26.

Table 26: City-Pairs by Level-of-Service Analyzed (Sample Corridors)

City-Pair		Level-of-Service
Terminus 1	Terminus 2	
Austin	Houston	Core Express
Waco	Houston	Regional
Waco	Houston	Emerging

The three variables determined to have the greatest impact on ridership were selected as the variables to be utilized in the uncertainty analysis; these are listed below along with the variations in values tested in the model for each input variable.

- Passenger Rail Fare: Three fare price (in 2010 dollars) levels – high, medium, and low were tested separately for each sample corridor as listed below.
  - Core Express: federal mileage rate fare, airfare fare, and midpoint between those two fares
  - Regional: fuel cost to drive fare, federal mileage rate fare, and midpoint between those two fares
  - Emerging: fuel cost to drive fare, federal mileage rate fare, and midpoint between those two fares
- Passenger Rail Average Operating Speed (determines trip time)
  - Core Express: 125 mph, 135 mph, 150 mph, 165 mph, 175 mph
  - Regional: 60 mph, 75 mph, 90 mph, 100 mph
  - Emerging: 30 mph, 40 mph, 50 mph, 60 mph
- Passenger Rail Weekend Ridership Factor
  - All levels of service: 0.6, 1.0, 1.6

The uncertainty analysis was intended to account for the different characteristics between corridors even though the Statewide Ridership Model used consistent assumptions statewide for all corridors as well as the uncertainty in the input variables. For example, although an average speed of 150 mph for core express service was utilized to produce ridership forecasts as reported in the technical memorandum for the cost effectiveness analysis, the actual average travel speed for a particular corridor may be higher or lower than 150 mph depending on the physical characteristics/ geometry of that corridor, which would be determined in a corridor level study. Furthermore, the fare rate per route mile for core express rail service within a particular corridor may be determined partly based on the competitiveness of available air service in that corridor and would likely vary by corridor.

The SAM-V2.5 travel demand model was utilized and run with each sample corridor included in one scenario to obtain the ridership for that specific corridor for the year 2035. For each potential intercity passenger rail corridor, different ridership was obtained with the variation of the following variables:

- Passenger Rail Fare
- Passenger Rail Average Operating Speed (determines trip time)

Fare and operating speed are important input to the SAM-V2.5 travel demand model, which affect the forecasted daily passenger rail ridership. In additional to these two variables, an off-model variable, Passenger Rail Weekend Ridership Factor, was also varied to examine the impact on the annual passenger rail ridership.

The resulting values of forecasted 2035 annual ridership associated with the variation in input values for each sample corridor are shown in Tables 27 through 29.

The forecasted annual ridership varies dramatically resulting from the changes in input variables tested. Changes in fare had the greatest impact on the forecasted annual ridership, with ridership increasing as the tested fares were decreased. The factor for weekend ridership was also varied to account for the fact that the Statewide Ridership Model only produces weekday ridership forecasts. The values used for the variation of this factor were based on NHTS survey data as well as weekend ridership vs. weekday ridership for other existing rail services and other ridership forecasting models. The forecasted annual ridership increased proportionally with the factor for weekend ridership.

Additionally, the forecasted annual ridership increased as the assumed average travel speeds were increased, since this would reduce trip times. The trip time is a major component of the mode choice model, though the model calculates trip time based on the input value of average travel speed.

Table 27: 2035 Ridership Data for Core Express Passenger Rail Service Sample Corridor (Austin to Houston)

Basis of Fare	Passenger Rail Fare	Avg. Speed (MPH)	Factor for Weekend Ridership	Week Daily Riders	Average Daily Riders	Total Annual Riders
Mileage	$ 91.57	175	1.6	10,965	16,246	5,929,933
Mileage	$ 91.57	165	1.6	10,691	15,840	5,781,474
Mileage	$ 91.57	150	1.6	10,218	15,140	5,526,074
Mileage	$ 91.57	135	1.6	9,654	14,304	5,220,936
Mileage	$ 91.57	125	1.6	9,213	13,650	4,982,172
Mileage	$ 91.57	175	1.0	10,965	12,497	4,561,487
Mileage	$ 91.57	165	1.0	10,691	12,184	4,447,287
Mileage	$ 91.57	150	1.0	10,218	11,646	4,250,826
Mileage	$ 91.57	135	1.0	9,654	11,003	4,016,105
Mileage	$ 91.57	125	1.0	9,213	10,500	3,832,440
Mileage	$ 91.57	175	0.6	10,965	9,998	3,649,189
Mileage	$ 91.57	165	0.6	10,691	9,747	3,557,830
Mileage	$ 91.57	150	0.6	10,218	9,317	3,400,661
Mileage	$ 91.57	135	0.6	9,654	8,802	3,212,884
Mileage	$ 91.57	125	0.6	9,213	8,400	3,065,952
Mid-point	$ 134.79	175	1.6	5,883	8,716	3,181,427
Mid-point	$ 134.79	165	1.6	5,681	8,418	3,072,414
Mid-point	$ 134.79	150	1.6	5,334	7,904	2,884,798
Mid-point	$ 134.79	135	1.6	4,921	7,291	2,661,160
Mid-point	$ 134.79	125	1.6	4,599	6,814	2,487,007
Mid-point	$ 134.79	175	1.0	5,883	6,705	2,447,252
Mid-point	$ 134.79	165	1.0	5,681	6,475	2,363,395
Mid-point	$ 134.79	150	1.0	5,334	6,080	2,219,075
Mid-point	$ 134.79	135	1.0	4,921	5,608	2,047,046
Mid-point	$ 134.79	125	1.0	4,599	5,241	1,913,083

Basis of Fare	Passenger Rail Fare	Avg. Speed (MPH)	Factor for Weekend Ridership	Week Daily Riders	Average Daily Riders	Total Annual Riders
Mid-point	$ 134.79	175	0.6	5,883	5,364	1,957,802
Mid-point	$ 134.79	165	0.6	5,681	5,180	1,890,716
Mid-point	$ 134.79	150	0.6	5,334	4,864	1,775,260
Mid-point	$ 134.79	135	0.6	4,921	4,487	1,637,637
Mid-point	$ 134.79	125	0.6	4,599	4,193	1,530,466
Air	$ 178.00	175	1.6	2,681	3,973	1,450,080
Air	$ 178.00	165	1.6	2,551	3,779	1,379,330
Air	$ 178.00	150	1.6	2,330	3,452	1,260,070
Air	$ 178.00	135	1.6	2,075	3,075	1,122,430
Air	$ 178.00	125	1.6	1,884	2,792	1,018,956
Air	$ 178.00	175	1.0	2,681	3,056	1,115,446
Air	$ 178.00	165	1.0	2,551	2,907	1,061,023
Air	$ 178.00	150	1.0	2,330	2,656	969,284
Air	$ 178.00	135	1.0	2,075	2,365	863,407
Air	$ 178.00	125	1.0	1,884	2,147	783,813
Air	$ 178.00	175	0.6	2,681	2,445	892,357
Air	$ 178.00	165	0.6	2,551	2,326	848,818
Air	$ 178.00	150	0.6	2,330	2,124	775,428
Air	$ 178.00	135	0.6	2,075	1,892	690,726
Air	$ 178.00	125	0.6	1,884	1,718	627,050

Table 28: 2035 Ridership Data for Regional Passenger Rail Service Sample Corridor (Waco to Houston)

Basis of Fare	Passenger Rail Fare	Avg. Speed (MPH)	Factor for Weekend Ridership	Week Daily Riders	Average Daily Riders	Total Annual Riders
Fuel	$ 32.11	100	1.6	10,762	15,946	5,820,265
Fuel	$ 32.11	90	1.6	9,986	14,795	5,400,282
Fuel	$ 32.11	75	1.6	8,538	12,650	4,617,236
Fuel	$ 32.11	60	1.6	6,589	9,763	3,563,326
Fuel	$ 32.11	100	1.0	10,762	12,266	4,477,127
Fuel	$ 32.11	90	1.0	9,986	11,381	4,154,063
Fuel	$ 32.11	75	1.0	8,538	9,731	3,551,720
Fuel	$ 32.11	60	1.0	6,589	7,510	2,741,020
Fuel	$ 32.11	100	0.6	10,762	9,813	3,581,702
Fuel	$ 32.11	90	0.6	9,986	9,105	3,323,251
Fuel	$ 32.11	75	0.6	8,538	7,785	2,841,376
Fuel	$ 32.11	60	0.6	6,589	6,008	2,192,816
Mid-point	$ 66.28	100	1.6	6,066	8,987	3,280,226
Mid-point	$ 66.28	90	1.6	5,486	8,128	2,966,805
Mid-point	$ 66.28	75	1.6	4,510	6,682	2,438,769
Mid-point	$ 66.28	60	1.6	3,310	4,904	1,790,060
Mid-point	$ 66.28	100	1.0	6,066	6,913	2,523,251
Mid-point	$ 66.28	90	1.0	5,486	6,252	2,282,158
Mid-point	$ 66.28	75	1.0	4,510	5,140	1,875,976
Mid-point	$ 66.28	60	1.0	3,310	3,773	1,376,970
Mid-point	$ 66.28	100	0.6	6,066	5,530	2,018,601
Mid-point	$ 66.28	90	0.6	5,486	5,002	1,825,726
Mid-point	$ 66.28	75	0.6	4,510	4,112	1,500,781
Mid-point	$ 66.28	60	0.6	3,310	3,018	1,101,576

Basis of Fare	Passenger Rail Fare	Avg. Speed (MPH)	Factor for Weekend Ridership	Week Daily Riders	Average Daily Riders	Total Annual Riders
Mileage	$ 100.46	100	1.6	3,273	4,850	1,770,094
Mileage	$ 100.46	90	1.6	2,941	4,357	1,590,284
Mileage	$ 100.46	75	1.6	2,417	3,581	1,307,151
Mileage	$ 100.46	60	1.6	1,792	2,655	969,028
Mileage	$ 100.46	100	1.0	3,273	3,730	1,361,611
Mileage	$ 100.46	90	1.0	2,941	3,351	1,223,295
Mileage	$ 100.46	75	1.0	2,417	2,755	1,005,501
Mileage	$ 100.46	60	1.0	1,792	2,042	745,406
Mileage	$ 100.46	100	0.6	3,273	2,984	1,089,289
Mileage	$ 100.46	90	0.6	2,941	2,681	978,636
Mileage	$ 100.46	75	0.6	2,417	2,204	804,401
Mileage	$ 100.46	60	0.6	1,792	1,634	596,325

Table 29: 2035 Ridership Data for Emerging Passenger Rail Service Sample Corridor (Waco to Houston)

Basis of Fare	Passenger Rail Fare	Avg. Speed (MPH)	Factor for Weekend Ridership	Week Daily Riders	Average Daily Riders	Total Annual Riders
Fuel	$ 33.71	60	1.6	5,710	8,460	3,087,929
Fuel	$ 33.71	50	1.6	4,247	6,292	2,296,525
Fuel	$ 33.71	40	1.6	2,735	4,052	1,479,069
Fuel	$ 33.71	30	1.6	1,372	2,033	742,164
Fuel	$ 33.71	60	1.0	5,710	6,508	2,375,330
Fuel	$ 33.71	50	1.0	4,247	4,840	1,766,558
Fuel	$ 33.71	40	1.0	2,735	3,117	1,137,746
Fuel	$ 33.71	30	1.0	1,372	1,564	570,896
Fuel	$ 33.71	60	0.6	5,710	5,206	1,900,264
Fuel	$ 33.71	50	0.6	4,247	3,872	1,413,246
Fuel	$ 33.71	40	0.6	2,735	2,494	910,196
Fuel	$ 33.71	30	0.6	1,372	1,251	456,717
Mid-point	$ 69.58	60	1.6	2,734	4,051	1,478,640
Mid-point	$ 69.58	50	1.6	1,997	2,959	1,080,043
Mid-point	$ 69.58	40	1.6	1,277	1,892	690,569
Mid-point	$ 69.58	30	1.6	645	955	348,721
Mid-point	$ 69.58	60	1.0	2,734	3,116	1,137,416
Mid-point	$ 69.58	50	1.0	1,997	2,276	830,803
Mid-point	$ 69.58	40	1.0	1,277	1,455	531,207
Mid-point	$ 69.58	30	1.0	645	735	268,247
Mid-point	$ 69.58	60	0.6	2,734	2,493	909,933
Mid-point	$ 69.58	50	0.6	1,997	1,821	664,642
Mid-point	$ 69.58	40	0.6	1,277	1,164	424,966
Mid-point	$ 69.58	30	0.6	645	588	214,598
Mileage	$ 105.45	60	1.6	1,460	2,164	789,755

Basis of Fare	Passenger Rail Fare	Avg. Speed (MPH)	Factor for Weekend Ridership	Week Daily Riders	Average Daily Riders	Total Annual Riders
Mileage	$ 105.45	50	1.6	1,071	1,587	579,242
Mileage	$ 105.45	40	1.6	685	1,016	370,687
Mileage	$ 105.45	30	1.6	354	525	191,605
Mileage	$ 105.45	60	1.0	1,460	1,664	607,504
Mileage	$ 105.45	50	1.0	1,071	1,221	445,571
Mileage	$ 105.45	40	1.0	685	781	285,144
Mileage	$ 105.45	30	1.0	354	404	147,388
Mileage	$ 105.45	60	0.6	1,460	1,332	486,003
Mileage	$ 105.45	50	0.6	1,071	977	356,457
Mileage	$ 105.45	40	0.6	685	625	228,115
Mileage	$ 105.45	30	0.6	354	323	117,910

The sample data provided by the model run outputs was limited to the three sample corridors and the variations of input variable previously listed, since this analysis was applied to a statewide model rather than a corridor model. In order to produce more accurate ridership estimates for any particular corridor, the input variables tested in this uncertainty analysis as well as others that may include the location of station stops, access and egress wait times at rail stations vs. airports in the corridor, etc. should be refined and tested in the model.

For this analysis, probability distributions were fitted to the sample data utilizing visual and mathematical procedures described in Appendix E in order to apply similar distributions to all of the statewide corridors based on the modelling results for the sample corridors. The supplied sample data was loaded into Oracle's Crystal Ball software containing goodness-of-fit algorithms to statistically determine an appropriate distribution.

Predictions of occurrence or reporting the probability of a particular value based on the fitted distributions are subject to uncertainty, which arises from the following conditions:

- The true probability distribution of events may deviate from the fitted distribution, as the observed data series may not be totally representative of the real uncertainty of occurrence of the phenomenon.

- The occurrence of events in another situation or in the future may deviate from the fitted distribution as this occurrence can also be subject to random error.
- A change of environmental conditions may cause a change in the probability of occurrence for the forecasted ridership. In the case of this analysis, a change in the controlled variables such as fare has a great impact on the ridership. As a result, the probability of occurrence for a particular range of ridership is dependent upon the decision of which range of fare will be used. Although the fare may be a controllable variable, it is still an unknown variable at this stage.

The fitted probability distributions shown may not actually reflect a true probability of occurrence, since the variable with the greatest impact on the annual forecasted ridership is the fare, which is a controllable variable and would therefore be optimized making the probability actually higher for some of the higher ridership values. However, at this stage the fare for each corridor is still unknown.

Distribution Fitting Results

Table 30 presents the forecasted 2035 intercity passenger rail annual ridership for the 3 sample corridors with the associated probability of occurrence in 5% increments, excluding the extremes of the distribution. The probability of the forecasted annual ridership for the first city-pair/level-of-service corridor listed can be communicated by the following statement: “There is a 70-percent probability that the annual ridership will be between 1.1 and 4.1 million riders for the Austin-Houston core express corridor.” As the variables are further defined, the range of estimated values for annual ridership for any given level of confidence will become smaller.

Table 30: Annual Ridership with Associated Confidence Level

Probability	Austin – Houston /Core Express	Waco – Houston /Regional	Waco – Houston /Emerging
85%	1,058,862	1,069,013	276,529
80%	1,203,128	1,192,508	323,945
75%	1,342,462	1,312,013	371,053
70%	1,481,288	1,431,284	419,168
65%	1,622,715	1,552,978	469,307
60%	1,769,382	1,679,364	522,417
55%	1,923,888	1,812,692	579,516
50%	2,089,111	1,955,461	641,800
45%	2,268,524	2,110,701	710,777
40%	2,466,616	2,282,337	788,464
35%	2,689,557	2,475,772	877,693
30%	2,946,344	2,698,898	982,677
25%	3,251,030	2,964,057	1,110,103
20%	3,627,533	3,292,274	1,271,534
15%	4,121,770	3,723,967	1,489,562

<u>Application of Sample Corridor Distributions to Remaining Corridors</u>

To fit the distributions from the sampled corridors to the non-sampled corridors with the same level of service, the fitted distributions were proportionally adjusted based on the relative size of a single ridership iteration that utilized the same underlying assumptions.

The table below displays an example relationship for core express service. The Austin – Houston corridor was sampled and the Houston – San Antonio corridor was not sampled.

Table 31: Example Relative Scale Comparison between Sampled and Non-Sampled Corridor

Austin – Houston Annual Ridership	Houston – San Antonio Annual Ridership	Relative Size
5,526,074	4,164,160	75.35%

This relational methodology assumed that the distribution derived from the sampled corridors would retain its shape for the non-sampled corridors. The only change in the distribution applied to the non-sampled corridors would be the ridership values assigned at each confidence interval along the distribution. This methodology assumes that the impact of fare and travel speed/ trip time on forecasted annual ridership would remain relatively consistent between corridors within each level of service. In addition to the bulleted reasons for uncertainty listed previously, applying a probability distribution from a sampled corridor to a non-sampled corridor causes the uncertainty to be enhanced.

Core Express Corridors

The results from fitting the scaled ridership probability distribution from the sample corridor to the remaining non-sample core express service corridors are shown in Table 32. The table shows the ranges of ridership for each corridor with a 70% probability of occurrence.

The Austin-Houston core express service corridor had the highest forecasted ridership, followed by Dallas to San Antonio, then Houston to San Antonio and Fort Worth to Houston (through Dallas). It should be noted however, that the Dallas-Fort Worth to Houston corridor has air service within the corridor at a level of competitiveness far above the other corridors as compared to the assumed passenger rail service. For example, there are approximately 50 flights each way with average fares comparable to the federal mileage rate for the Dallas-Fort Worth corridor, while there are only 10 to 15 flights per day in each direction with fares well above the federal mileage rate in the Austin to Houston corridor. As a result, the Dallas-Fort Worth to Houston corridor may warrant further detailed analysis to determine the impact of corridor-specific fares and travel speed/ trip times (competitive with air service) on forecasted ridership, since the overall travel demand for that corridor is actually significantly higher than the Austin to Houston corridor.

Table 32: Core Express Service Ridership Uncertainty Results

Origin	Destination	Upfront Capital Cost	Annual O&M Cost	2035 Annual Ridership (P70)
Austin	Houston	$11B	$125M	1.1M – 4.1M
Houston	San Antonio	$13.3B	$152M	0.8M – 3.1M
Dallas	Houston	$18.3B	$209M	0.7M – 2.7M
Dallas	Austin	$15.2B	$273M	0.8M – 2.9M
Fort Worth	Houston	$20.4B	$234M	0.7M – 2.8M
Dallas	San Antonio	$20.4B	$234M	0.9M – 3.7M
Dallas	Oklahoma City	$15.5B	$177M	0.5M – 1.8M
DFW/ Airport	Houston	$19.2B	$220M	0.5M – 2.1M
Austin	San Antonio	$5.4B	$61M	52K – 201K

Regional Corridors

The results from fitting the scaled ridership probability distribution from the sample corridor to the remaining non-sample regional service corridors are shown in Table 33. The table shows the ranges of ridership for each corridor with a 70% probability of occurrence. The Waco to Houston regional service corridor had the highest forecasted ridership, followed by Fort Worth to Baton Rouge.

Table 33: Regional Service Ridership Uncertainty Results

Origin	Destination	Upfront Capital Cost	Annual O&M Cost	2035 Annual Ridership (P70)
Waco	Houston	$6.3B	$91M	1.1M – 3.7M
Fort Worth	Bryan-College Station	$6.8B	$97M	0.7M – 2.3M
Houston	Killeen	$6.6B	$94M	0.7M – 2.3M
Tyler	Houston	$6.9B	$99M	0.4M – 1.5M
Fort Worth	Baton Rouge	$14.8B	$215M	1M – 3.5M

Emerging Corridors

The results from fitting the scaled ridership probability distribution from the sample corridor to the remaining non-sample emerging service corridors are shown in Table 34. The table shows the ranges of ridership for each corridor with a 70% probability of occurrence. The Waco to Houston and Tyler to Houston emerging service corridors had the highest forecasted ridership.

Table 34: Emerging Service Ridership Uncertainty Results

Origin	Destination	Upfront Capital Cost	Annual O&M Cost	2035 Annual Ridership (P70)
Waco	Houston	$3.1B	$19M	0.3M – 1.5M
Tyler	Houston	$4.6B	$27M	0.3M – 1.5M
Killeen	Houston	$3.5B	$20M	0.2M – 0.9M
Fort Worth	Baton Rouge	$7.4B	$44M	0.2M – 0.5M
Fort Worth	Bryan-College Station	$3.4B	$20M	90K – 0.5M
Beaumont	Brownsville	$8.1B	$48M	0.2M – 1M

<u>Dallas/ Fort Worth to Houston and Dallas/ Fort Worth to San Antonio Corridors</u>

The preliminary ridership results as produced in the cost effectiveness analysis and probability analysis tasks showed the forecasted ridership for the Dallas/ Fort Worth to Houston corridor to be significantly lower than some of the other core express service corridors evaluated, such as the Austin to Houston and Dallas to San Antonio corridors. However, these results were further analyzed, since the Dallas/ Fort Worth to Houston corridor has an overall higher number of intercity travellers (all modes combined) than the other corridors. It was determined that the highly competitive nature of air service within the Dallas/ Fort Worth to Houston corridor, with two major airports at each terminus and approximately 50 flights per day in each direction at fares nearly equal to the federal mileage rate, would require the assumptions for high speed rail service in that corridor would need to be modified to be more competitive with the air service. As a result, an optimized run was performed for the Dallas/ Fort Worth to Houston corridor to better reflect the likely characteristics of potential high speed rail service in that corridor. The characteristics utilized in the optimized model run were based on publicized assumptions being used by the Texas Central Railway, the private consortium currently pursuing high speed rail between Dallas/ Fort Worth and Houston, which consisted of the modifications listed below.

- Removed station stop at College Station
- Reduced fare to 80% of average airfare ($108 between Dallas and Houston)
- Increased average travel speed to 160 mph to produce an approximate trip time of 90 minutes between Dallas and Houston

The above listed modifications results in a forecasted ridership that more than doubled from the original model run for the Dallas/ Fort Worth to Houston corridor, increasing from 3.8 million annual riders to 7.8 million annual riders. The estimated capital costs also changed for the modified Dallas/ Fort Worth to Houston corridor, since removing the College Station stop allowed for a more direct route and reduced the route length (reduced capital cost) and the revised ridership forecast required additional trainsets to provide the required capacity (increased capital cost). The estimated annual operating and maintenance costs were also revised to account for the additional trainsets, and therefore train miles, that would be required by the increased ridership.

Following the analysis of the Dallas/ Fort Worth to Houston corridors, the remaining core express corridors were reviewed to determine if they had similarly competitive air service. Of the remaining core express corridors, only the Dallas to San Antonio corridor has air service with fares nearly equal to or less than the federal mileage rate fare used in the model as the low fare for high speed rail service. As a result, an optimized run was performed for the

Dallas to San Antonio corridor with the high speed rail fare reduced to 80% of the average airfare. The reduction in the fare for the Dallas to San Antonio corridor resulted in an 80% increase in high speed rail ridership from 4.9 million annual riders to 8.8 million annual riders. The estimated capital costs were also modified for the modified Dallas to San Antonio corridor, since the revised ridership forecast required additional trainsets to provide the required capacity (increased capital cost). The estimated annual operating and maintenance costs were also revised to account for the additional trainsets, and therefore train miles, that would be required by the increased ridership.

Detailed results from the optimized Dallas/ Fort Worth to Houston and Dallas to San Antonio core express service corridors are shown in Appendix F of this report. The probability distribution was then revised for the Dallas/ Fort Worth to Houston and Dallas to San Antonio core express corridors based on the modified ridership data. Table 35 shows the ranges of forecasted ridership for the core express service corridors, with the values revised for the Dallas/ Fort Worth to Houston corridors based on the above discussed modified assumptions.

Table 35: Core Express Service Ridership Uncertainty Results – Dallas/ Fort Worth to Houston and Dallas to San Antonio Corridors

Origin	Destination	Upfront Capital Cost	Annual O&M Cost	2035 Annual Ridership (P70)
Dallas	Houston	$16.8B	$266M	1.5M – 5.7M
Fort Worth	Houston	$19B	$301M	1.5M – 5.8M
DFW/ Airport	Houston	$17.4B	$276M	1.5M – 5.4M
Dallas	San Antonio	$20.7B	$351	1.7M – 6.5M

The results of the optimized runs further demonstrate the direct relationship between the fare and forecasted ridership for the potential intercity passenger rail corridors. While the probability analysis accounted for variations in fares, the optimized runs shown in Table 35 were performed to account for corridors where there was little difference between the low fares (federal mileage rate) and high fares (airfare).

7.0 Summary of Results

The Statewide Ridership Analysis was completed to provide a high level evaluation of forecasted ridership and cost effectiveness for various corridors in the state in order to determine which corridors may warrant further analysis, should funding become available, and what level(s) of service may be supported by the different corridors. The analysis was not intended to provide a detailed ridership analysis of any individual corridor, since many assumptions were applied to all of the corridors statewide and would need to be modified to more accurately reflect the characteristics of any particular corridor. However, care was taken to account for the variability and uncertainty in the forecasted ridership results produced as reported in ranges shown in the summary tables below.

Table 36: Core Express Service Ridership Summary Results[9] [10]

Origin	Destination	Upfront Capital Cost	Annual O&M Cost	2035 Annual Ridership (P70)
Austin	Houston	$11B	$125M	1.1M – 4.1M
Houston	San Antonio	$13.3B	$152M	0.8M – 3.1M
Dallas	Houston	$16.8B	$266M	1.5M – 5.7M
Dallas	Austin	$15.2B	$273M	0.8M – 2.9M
Fort Worth	Houston	$19B	$301M	1.5M – 5.8M
Dallas	San Antonio	$20.7B	$351M	1.7M – 6.5M
Dallas	Oklahoma City	$15.5B	$177M	0.5M – 1.8M
DFW/ Airport	Houston	$17.4B	$276M	1.5M – 5.4M
Austin	San Antonio	$5.4B	$61M	52K – 201K

[9] Dallas/ Fort Worth region to Houston and Dallas to San Antonio corridor results shown in Table 36 are based on the optimized model runs performed with decreased fares to account for competitive air fares in those corridors rather than federal mileage rate fares utilized for other corridors.

[10] Forecasted passenger rail ridership reported does not include induced ridership.

Table 37: Regional Service Ridership Summary Results[11]

Origin	Destination	Upfront Capital Cost	Annual O&M Cost	2035 Annual Ridership (P70)
Waco	Houston	$6.3B	$91M	1.1M – 3.7M
Fort Worth	Bryan-College Station	$6.8B	$97M	0.7M – 2.3M
Houston	Killeen	$6.6B	$94M	0.7M – 2.3M
Tyler	Houston	$6.9B	$99M	0.4M – 1.5M
Fort Worth	Baton Rouge	$14.8B	$215M	1M – 3.5M

Table 38: Emerging Service Ridership Summary Results[12]

Origin	Destination	Upfront Capital Cost	Annual O&M Cost	2035 Annual Ridership (P70)
Waco	Houston	$3.1B	$19M	0.3M – 1.5M
Tyler	Houston	$4.6B	$27M	0.3M – 1.5M
Killeen	Houston	$3.5B	$20M	0.2M – 0.9M
Fort Worth	Baton Rouge	$7.4B	$44M	0.2M – 0.5M
Fort Worth	Bryan-College Station	$3.4B	$20M	90K – 0.5M
Beaumont	Brownsville	$8.1B	$48M	0.2M – 1M

The ridership forecasts shown in the tables above are based on the corridors being implemented singularly, and do not account for the corridors acting as part of a system. A Core System was evaluated by combining high-performing individual corridors based on professional judgment and the rankings from the travel market and cost effectiveness analyses. The Core System is shown in Figure 10 and the resulting performance of the Core System is summarized in Table 39.

[11] Forecasted passenger rail ridership reported does not include induced ridership.

[12] Forecasted passenger rail ridership reported does not include induced ridership.

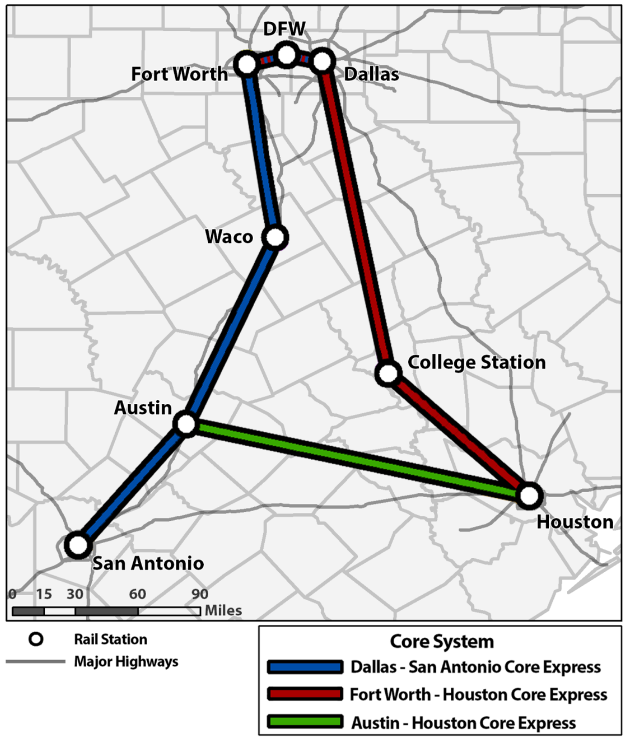

Figure10: Core System Route Concept

Table 39: Core System Performance Measures[13]

Performance Measure	Upfront Capital Cost	2035 Annual Ridership
System Total	**$48.5**	**4.3M – 16.4M**
Total Revenue: Dallas – San Antonio Core Express	$20.7B	1.7M – 6.5M
Total Revenue: Fort Worth – Houston Core Express	$16.8B	1.5M – 5.8M
Total Revenue: Austin – Houston Core Express	$11B	1.1M – 4.1M

After the Core System was run, additional corridors were added iteratively to the Core System to create new candidate systems. When run together in various combinations as part of a system, the results generally showed that while each additional corridor had its own independent utility, the addition of new corridors to the core system caused the cost effectiveness of the system to decrease due to higher system costs and somewhat redundant services. For example, the decrease in forecasted ridership and revenue along the Austin to Houston corridor resulting from adding the San Antonio to Houston corridor

[13] Dallas/ Fort Worth region to Houston and Dallas to San Antonio corridor results shown in Table 39 are based on the optimized model runs performed with decreased fares to account for competitive air fares in those corridors rather than federal mileage rate fares utilized for other corridors.

and the overall significant reduction in the system cost recovery ratio implies that the two core express corridors are somewhat redundant. Similar results were found for the Waco to Houston and Killeen to Houston corridors.

Additionally, there were negligible transfers between the Dallas/ Fort Worth to Houston and the Dallas/ Fort Worth to San Antonio corridors. This is due to the nature of the geography for those two corridors, which essentially form the sides of a triangle. For example, the cost and trip time required to get between Houston and Waco would not be competitive via transfer between the two core express routes (going through Dallas/ Fort Worth) as compared to either driving or flying directly between the two cities. As a result, there was little system effect to the individual corridor ridership of including these two corridors together in a system. However, the ridership was increased by combining the Austin to Houston and Dallas/ Fort Worth to San Antonio corridors in a system, as there were transfers between those two routes. In conclusion, a “triangle system” causes little increase to corridor ridership forecasts, while a “T” system would experience greater transfers and resulting increases to individual corridor ridership forecasts.

Lastly, the mode share of each of the corridors analyzed in the system optimization analysis was evaluated as shown in Table 40. As previously discussed, modification of the fare has a significant impact on the forecasted passenger rail ridership and would therefore impact the mode shares shown below.

Table 40: Corridor Mode Share Summary Results (based on federal mileage rate used for passenger rail fare)

Corridor	Upfront Capital Cost	Auto Mode Share	Air Mode Share	Intercity Passenger Rail Mode Share
Dallas – San Antonio Core Express	$20.7B	25%	12%	63%
Fort Worth – Houston Core Express	$19B	39%	8%	53%
Austin – Houston Core Express	$11B	50%	3%	47%
San Antonio – Houston Core Express	$13.3B	56%	5%	39%
Oklahoma City – Dallas Core Express	$15.5B	60%	9%	31%
Waco – Houston Regional Rail	$6.3B	99%	0%	1%
Killeen – Houston Regional Rail	$6.6B	99%	0%	1%
Tyler – Houston Emerging Rail	$4.6B	88%	5%	7%
Fort Worth-Baton Rouge Regional Rail	$14.8B	36%	62%	2%

Appendices

Appendix A - Matrix of City Pairs and Service Level Assumptions

Appendix B – Probability Analysis of Cost Estimates Technical Memorandum

Appendix C – Cost Effectiveness Analysis Technical Memorandum

Appendix D – System Optimization Analysis Technical Memorandum

Appendix E – Probability Analysis Technical Memorandum

Appendix F – Optimized Dallas/ Fort Worth to Houston and Dallas/ Fort Worth to San Antonio Model Results

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