Appendix G
Travel Forecasting Methodology

Appendix G: Passenger Rail Ridership Forecasting Methodology

This appendix details the travel demand model used to produce passenger rail ridership forecasts for the Richmond/Hampton Roads Passenger Rail Project. The forecasting portion of the study was conducted over two time periods. The original model was developed in 2004, with updates applied to components of the model in 2008. The document describes the original 2004 model development process, providing special note of components updated in 2008.

The ridership and revenue forecasts were created through the application of travel demand models previously developed for use in the southeastern United States and applied throughout the country.[1] As described in the following sections, the model is based on: 1) data collected within the study area; 2) data provided by the Metropolitan Planning Organizations (MPOs) and other local sources within the study area; (3) data collected for previous studies in the northeast and southeast United States; and 4) data provided by national sources. The data include base and future travel volumes within the study area, present socio-economic data and future projections, and travel service data throughout the study area.

MPOs are responsible for local transportation planning and policy decisions within their metropolitan regions. The Richmond/Hampton Roads study area contains three MPOs:

- Hampton Roads Planning District Commission (HRPDC);
- Richmond Regional Planning District Commission (RRPDC); and
- Crater Planning District Commission (CPDC).

Since each MPO has developed extensive transportation planning data and forecasts, the travel demand model used for this project preserves and applies the local MPO data where possible. The following sections describe the integration of the MPO data into the travel demand model.

The analysis and prediction of future passenger rail travel demand began with the development of study area boundaries and then quantifying existing travel by mode, geography and trip purpose. This analysis included an examination of existing automobile, air , rail and intercity bus travel trips to and from the Hampton Roads region.

Development of Travel Demand Study Area Boundaries

A common geographic based zone system was developed for the travel demand analysis. This zone system defines the geographic level of detail at which the forecasting

[1] Phase II – New Orleans to Mobile Corridor Development Plan, Ridership and Revenue Forecasts prepared for Southern Rapid Rail Transit Commission (January 2005); Pacific Northwest Rail Corridor, Ridership and Revenue Forecasts in Support of the Amtrak Cascades Plan for Washington State 2003-2023 Update (July 2003); Southeast High Speed Rail (SEHSR) and other corridor studies in the Southeast (1997-date); California intercity passenger rail forecasting in the Pacific Surfliner, Capitol, and San Joaquin corridors for Amtrak and California (1996-date)

process is applied. Socio-economic data, travel market data and network/service characteristics were all defined for this zone system.

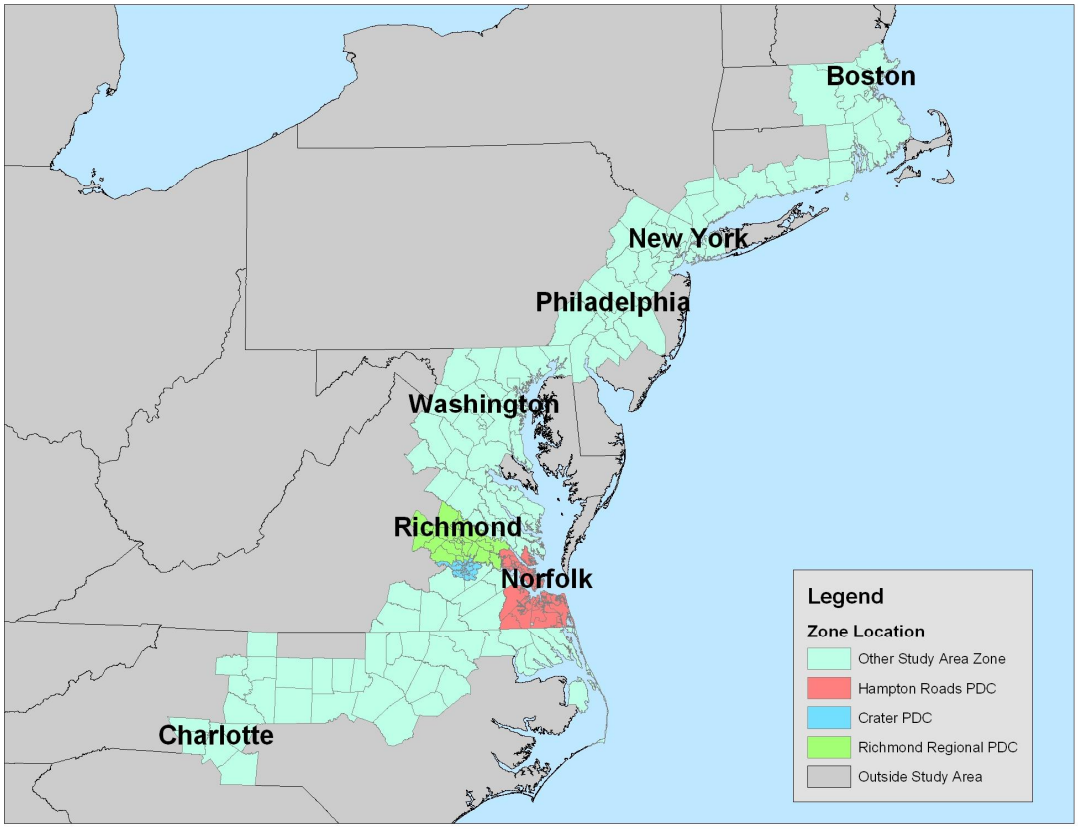
The study area zone system is based on county boundaries and the traffic analysis zones (TAZs) of the three MPOs within the Richmond/Hampton Roads study area.

Since the TAZs are designed for local analysis by the MPOs, the number and size of the TAZs makes them impractical for an intercity study. Thus, the study area zones within the Richmond/Hampton Roads study area are composed of aggregated MPO TAZs. Though the TAZs were aggregated for the purpose of the study zone system, most of the TAZ-specific data, such as demographic data and highway access information, were preserved and applied in this study, as described later in this report. The aggregation preserved county boundaries, as each study area zone falls within one unique county.

In some cases, the MPO TAZs only account for a portion of a county, with the remainder of the county outside the MPO boundaries. In these cases, the TAZs from the partial county were aggregated into one or more zones, and the remainder of the county not accounted for by the MPO formed another zone. Zones outside of the Richmond/Hampton Roads study area are defined by county boundaries, with each zone representing one county.

The entire zone system is composed of 215 zones. Eighty-nine zones are aggregated MPO zones, and the remaining 126 are county-based zones. Figure 1 below provides an overview of the study area and the zone system developed for the project.

Figure 1 Overview of Travel Demand Study Area and Zone System



Travel Market Analysis

Once the study boundaries were defined, the existing travel by mode, geography and purpose was quantified. In 2004, current person-travel volumes were estimated with data from license plate surveys conducted in the Richmond/Hampton Roads study area, supplemented with data from a variety of existing sources. With the exception of Amtrak data, which provided the basis for the travel demand model, the analysis did not include collection of new travel market data. The 2004 data was updated to 2007 figures for use in the updated analysis.

Existing Automobile Trips

A detailed description of the methodology used to compile the travel volume data used in this analysis from license plate surveys and other sources into a comprehensive estimate of market size for the travel demand study area is contained in the Travel Demand Methodology and Results Report (April 2005, revised March 2008, http://www.rich2hrrail.info/pages/mp_reports.html). The estimated current person travel volume by automobile was estimated from a combination the following sources:

- Origin-destination license plate survey conducted at two locations in the Richmond/Hampton Roads study area in September 2004.
- Origin-destination data compiled as part of a 1994 survey for the Chesapeake Bay Bridge-Tunnel (CBBT) Study;
- Origin-destination data collected in 1995 in conjunction with data from the Southeast High Speed Rail Study.

Existing Rail Trips

Amtrak provides two daily round trip trains along the Peninsula/CSXT route today. The trains provide service to the Newport News, Williamsburg, and Richmond Main Street Amtrak stations, and continue through Richmond to provide direct service to Washington DC, New York, Boston and the other major markets in the Northeast Corridor. Passengers traveling to and from Newport News and Williamsburg are able to make trips to North Carolina and the southeast through a transfer in Richmond.

Amtrak provided actual 2007 ridership and revenue data for all direct service to/from Hampton Roads, and for trips between Hampton Roads and North Carolina (which require a transfer in Richmond). In 2007, approximately 160,000 passengers traveled to/from the Hampton Roads stations of Williamsburg and Newport News, including direct trips to other locations in Virginia, destinations in the Northeast Corridor, and transfers to destinations in North Carolina.

Existing Air Travel Trips

Norfolk International, Newport News-Williamsburg International and Richmond International airports provide direct service from the Richmond/Hampton Roads study area to all major airports in the Northeast Corridor and North Carolina. Existing air travel trips were developed from a passenger person-trip table from the 1995 SEHSR study combined with actual 2004 air data.

The air travel trips in the SEHSR trip table were developed from passenger surveys conducted in 1995. The trips corresponded to the SEHSR zone system, and were converted to represent the zone system used in this study. A description of the methodology used to convert the trip data is described in detail in the Travel Demand Methodology and Results Report (April 2005, revised March 2008).

Existing Intercity Bus Trips

Greyhound intercity bus service with six direct daily round trips between Norfolk and Richmond along the Peninsula/CSXT route, but provides limited direct service to destinations outside of the Richmond/Hampton Roads study area. Greyhound provides one daily direct round trip between Norfolk and Washington, DC, three direct daily round trips between Norfolk and New York, NY, and no direct daily round trips between Norfolk and Charlotte, NC.

Greyhound declined requests to provide actual 2004 ridership and revenue data for this study. Intercity bus trips represent a small fraction of the total travel market; their absence from the total market estimation is not significant and does not significantly affect the study.

Market Growth

Socio-economic data and forecasts were used to estimate market growth. These data were obtained as part of the 2008 project update from local and state sources within the Richmond/Hampton Roads study area, supplemented by the national vendor, Moody's Economy.com. Table 1 summarizes the sources of socio-economic data by data type and location.

Table 1 Socio-Economic Data Sources

Data	Source		
	Population Data	**Employment Data**	**Income Data**
Study Area Zones	HRPDC / RRPDC/ CPDC	HRPDC / RRPDC/ CPDC	Economy.com
County Based Zones	Virginia Employment Commission	Economy.com	Economy.com
Other County Based Zones	Economy.com	Economy.com	Economy.com

Notes:
HRPDC = Hampton Roads Planning District Commission
RRPDC = Richmond Regional Planning District Commission
CPDC = Crater Planning District Commission

The RRPDC and CPDC provided 2000 data and 2031 projections, while the HRPDC provided 2000 data and 2030 projections. For consistency with the updated base year of 2007 used in this analysis, the 2000 socio-economic data were projected to 2007. Also, for consistency with the forecast year of the overall project, the projections were scaled back to 2025.

The 2000 and 2007 county level population and employment data provided by Moody's Economy.com were used to compute the 2000 to 2007 growth, by county. The Moody's Economy.com 2025 and 2030/2031 population and employment projections were also used to convert the 2030/2031 MPO projections to 2025. The process by which the data

was converted is described in detail in the Travel Demand Methodology and Results Report (April 2005, revised March 2008, http://www.rich2hrrail.info/pages/mp_reports.html). Table 2 provides a summary of 2007 and 2025 socio-economic data for the study area.

Table 2 Summary of Socio-Economic Data in the Travel Demand Study Area

	Population			Employment			Per Capita Income (2000 $)		
Areas within Study Area	**2007**	**2025**	**Avg. Annual Growth**	**2007**	**2025**	**Avg. Annual Growth**	**2007**	**2025**	**Avg. Annual Growth**
Hampton Roads (Southside)	1,108,643	1,288,386	0.84%	726,525	798,403	0.53%	$31,374	$42,071	1.64%
Hampton Roads (Peninsula)	495,245	611,135	1.17%	304,132	359,911	0.94%	$30,105	$38,787	1.42%
Richmond Area	928,222	1,216,920	1.52%	655,074	832,663	1.34%	$35,213	$48,831	1.83%
Petersburg Area	156,715	211,828	1.69%	65,061	112,008	3.06%	$27,032	$35,426	1.51%
Virginia Other - North of Richmond	2,645,604	3,534,065	1.62%	1,364,639	1,876,238	1.78%	$46,274	$67,424	2.11%
Virginia Other - South of Richmond	146,261	157,656	0.42%	84,831	125,157	2.18%	$21,422	$25,213	0.91%
North Carolina	4,977,492	6,396,710	1.40%	2,456,378	3,586,301	2.12%	$30,869	$41,412	1.65%
DC/Maryland/ Pennsylvania/ Delaware	10,002,489	10,480,075	0.26%	5,234,217	6,110,326	0.86%	$40,421	$51,625	1.37%
New Jersey/New York	17,956,814	18,107,692	0.05%	8,340,069	9,431,375	0.69%	$43,270	$56,359	1.48%
New England	8,660,870	8,829,749	0.11%	4,265,735	4,826,474	0.69%	$42,625	$55,074	1.43%

Note: The data only represents the portion of these areas within the study area. The data does not sum to totals for the states represented.
Source: *Travel Demand Methodology and Results,* as revised March 2008 (http://www.rich2hrrail.info/pages/mp_reports.html).

Travel Demand Model and Inputs

The travel demand modeling approach used for this project is based on a model system developed for use in previous applications to evaluate proposed high speed rail and intercity rail services for several states and Amtrak throughout the country[2]. The travel demand model was developed from extensive market research and observed travel volumes and service characteristics by mode that were conducted and assembled in

[2] Phase II – New Orleans to Mobile Corridor Development Plan, Ridership and Revenue Forecasts prepared for Southern Rapid Rail Transit Commission (January 2005); Pacific Northwest Rail Corridor, Ridership and Revenue Forecasts in Support of the Amtrak Cascades Plan for Washington State 2003-2023 Update (July 2003); Southeast High Speed Rail (SEHSR) and other corridor studies in adjacent states in the Southeast (1997-date); California intercity passenger rail forecasting in the Pacific Surfliner, Capitol, and San Joaquin corridors for Amtrak and California (1996-date)

study area markets in the southeast and other regions. For application to this project, data describing travel within the Richmond/Hampton Roads study area were used, including existing person trips by mode and purpose, and population/employment market growth, as described above. A detailed explanation of the methodology and assumptions used in the travel demand model is contained in the Travel Demand Methodology and Results Report (April, 2005, revised March 2008, (http://www.rich2hrrail.info/pages/mp_reports.html)).

Model Structure

The travel demand forecasting approach utilized a two-stage model system. The first stage forecasted growth in the total number of travel trips in each market, and the second stage predicted the market share of each available travel mode in each market. Both stages were dependent on the service characteristics of each travel mode and the characteristics of the study area population. The key markets addressed in the forecasting model system were defined by geographic location (i.e., origin-destination zone pair, based on the zone system described above) and trip purpose (i.e., business, recreation or other).

The first stage addresses growth in the total intercity travel trip volumes. This includes natural growth and induced demand. The natural growth component is based on the growth in population and total employment in the study area. (a summary of population and employment growth projections is provided in the section above). The induced component measures the additional demand created as a result of increased capacity and improvements in the transportation system.

The second stage of the model is the travel mode share component, which estimates the share of total trips by mode. Three modes of travel are considered: auto, rail and air. The key variables in the travel mode share model include the following:

- On-mode travel time for all modes;
- Access/egress time for rail and air;
- Travel cost or fare;
- Frequency of service for rail and air;
- On-time performance (OTP) for rail;
- Income differences to account for differences in value of time; and
- Mode specific constants reflecting all differences between modes which are not accounted for in the other independent variables.

Networks and Service Characteristics

Service characteristics are the key independent variable for the travel mode choice modeling process. The model uses the following service characteristics:

- Travel time (minutes)
- Travel cost (dollars)
- Frequency (departures per day)
- Time of day of service

Highway Network and Automobile Service Characteristics

The automobile service characteristics for each study area zone pair, including time, distance and cost; were developed using a GIS-based intercity highway network. The highway network was built from four sources:

- Richmond Regional PDC provided the congested highway networks and the TAZ system for the Richmond metropolitan area in TRANPLAN[3] model format for the years 2000 and 2026.
- Crater PDC provided the congested highway networks and the TAZ system for the Petersburg metropolitan area in TRANPLAN model format for the years 2000 and 2026.
- Hampton Roads PDC provided the congested highway networks and the TAZ system for the Hampton Roads area in TRANPLAN model format for the years 2000 and 2026.
- Oak Ridge National Laboratory's highway network was used to build the highway network for the rest of the study area.

The 2026 highway networks obtained from the Richmond, Petersburg and Hampton Roads MPOs represent the adopted cost-feasible transportation plan of each MPO, effective in 2004. New networks were not obtained as part of the updated analysis.

In the 2004 analysis, two modifications to the HRPDC highway network were made in response to comments from the Hampton Roads PDC. First, additional travel time was added to the Hampton Roads bridges and tunnels in the existing and future networks to account for unexpected delay. Travelers typically add extra time for trips across these bridges and tunnels to account for unexpected delays due to accidents and/or congestion.

Second, the future assumptions relating to the proposed First Phase of the Third Hampton Roads Crossing were modified. In the HRPDC 2026 future highway network, the proposed First Phase of the Third Crossing is modeled as a high-occupancy toll facility, where vehicles with single occupants would pay a $5.38 toll, and vehicles with more than one occupant would cross the facility for free. Based on guidance from the HRPDC staff, the revised network now reflects the proposed First Phase as a toll facility, with all future traffic paying a $5.38 toll.

Based on the combined network, reflecting the three local MPO networks and the Oak Ridge network, automobile travel times were developed for all zone-to-zone pairs in the study area. Each minimum path calculation developed the time, distance and toll costs associated with the trip.

Automobile operating costs were then computed by applying the following average costs per mile to the zone-to-zone distance:

- $0.486 per mile for business travel - represents a fully allocated cost, including fixed costs reflected in typical business travel reimbursement policies[4].
- $0.166 per mile for non-business travel - reflects only the incremental out-of-pocket costs.

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[3] TRANPLAN is a specialized computer software package used for travel demand modeling.

[4] Based on the Internal Revenue Service standard mileage rate for business use of an automobile

The costs are expressed in 2007 dollars and represent cost per vehicle. The total vehicle cost was divided by average vehicle occupancy to calculate the automobile cost per person in the mode choice model.

Table 3 summarizes the automobile distance, travel time, average speed and toll costs in several key markets in the study area.

Table 3 Summary of Automobile Trip Characteristics for Selected Markets

Origin City	Destination City	2000 Highway Characteristics				2025 Highway Characteristics			
		Distance (miles)	Time	Tolls	Speed (mph)	Distance (miles)	Time	Tolls	Speed (mph)
Norfolk	Richmond	101	2:08	-	47	100	2:28	$5.38	40
Norfolk	Washington, D.C.	211	3:52	-	55	204	5:01	$5.38	41
Norfolk	New York, NY	359	6:45	$23.14	53	359	8:42	$23.14	41
Norfolk	Boston, MA	564	10:24	$27.51	54	565	13:27	$27.51	42
Virginia Beach	Richmond	105	2:24	-	44	107	2:37	$5.38	41
Virginia Beach	Washington, D.C.	208	4:07	-	50	212	5:10	$5.38	41
Virginia Beach	New York, NY	355	6:43	$23.14	53	354	8:38	$23.14	41
Virginia Beach	Boston, MA	560	10:22	$27.51	54	560	13:23	$27.51	42
Newport News	Richmond	80	1:53	-	42	83	2:02	-	41
Newport News	Washington, D.C.	183	3:35	-	51	188	4:35	-	41
Newport News	New York, NY	373	7:06	$23.14	52	370	8:54	$28.52	42
Newport News	Boston, MA	579	10:45	$27.51	54	575	13:39	$32.89	42
Williamsburg	Richmond	51	1:03	-	48	52	1:20	-	39
Williamsburg	Washington, D.C.	154	2:45	-	56	157	3:53	-	40
Williamsburg	New York, NY	382	6:45	$17.64	56	385	9:04	$17.64	42
Williamsburg	Boston, MA	587	10:24	$22.01	56	590	13:49	$22.01	43

Source: *Travel Demand Methodology and Results,* revised March 2008.

Rail and Air Service Characteristics

Travel characteristics for rail and air travel were developed for each study area zone pair. The travel characteristics for rail and air were based on published timetables and the highway network. The key characteristics include travel time, frequency of service, fares, terminal times, access/egress times and costs, and rail on-time performance. The travel time is the scheduled rail/air time between stations/airports.

Published Amtrak timetables (2007) provided the basis for quantifying the travel time and frequency of service in each market. Average rail fares were computed by dividing actual Amtrak revenue by ridership and airfares. According to Amtrak, current (2007) on-time performance of trains serving the Richmond/Hampton Roads Corridor is approximately 72 percent.

Current (2004) market based air data, including travel times and fares, were provided by an outside vendor, BACK Associates.

Table 4 provides a summary of the key base year (2007) rail and air characteristics, in comparison to automobile, for sample trips between downtown Newport News and Washington, DC, and between downtown Norfolk and Washington, DC. The access/egress times and costs include the time/cost of traveling from the origin zone to the boarding rail station/airport; the time/cost associated with the station, including waiting/boarding times and parking costs; and the time/cost of traveling from the

destination station/airport to the final destination zone. Access/egress times and costs for travel between zones and stations/airports were developed using the same network procedure and cost per mile rates described above and used for the auto zone-to-zone travel characteristics. The data in Table 4 indicate that while air travel has the shortest time, it has the highest cost. Rail has a moderate cost, but the longest time and auto travel has the least cost but a moderate time.

Table 4 Summary of Base Year (2007) Travel Characteristics by Mode for Select Markets

		Newport News - Washington, D.C.			Norfolk - Washington, D.C.		
		Auto	**Rail**	**Air**	**Auto**	**Rail**	**Air**
Through Travel by Mode							
	Stations/Airports		NPN-WAS	ORF-BWI		NPN-WAS	ORF-BWI
	Distance (miles)	183	187	158	211	187	158
	Travel Time	3:35	4:13	0:48	3:52	4:13	0:48
	Highway Cost[1]	$31.11			$35.03		
	One-way Fare		$42.00	$66.00		$42.00	$66.00
	Daily Round Trips		2	6		2	6
	On-time performance (Rail Only)		72%			72%	
Access to Mode							
	Distance (miles)		4	22		22	8
	Highway Time		0:08	0:33		0:33	0:15
	Station/Terminal Time		0:10	0:30		0:10	0:30
	Travel Cost[1]		$0.68	$3.74		$3.74	$1.36
Egress From Mode							
	Distance (miles)		3	31		3	31
	Highway Time		0:10	0:39		0:10	0:39
	Station/Terminal Time		0:15	0:35		0:15	0:35
	Travel Cost[1]		$0.51	$5.27		$0.51	$5.27
Total Travel Time		3:35	4:56	3:11	3:52	5:21	2:47
Total Travel Cost[1]		$31.11	$43.19	$75.01	$35.03	$46.25	$72.63

[1] Auto cost displayed for non-business travel, $0.17 per mile (2007 dollars)
Source: *Travel Demand Methodology and Results,* revised March 2008.
NPN-WAS = Newport News Station to Washington D.C. Union Station
ORF-BWI = Norfolk International Airport to Baltimore-Washington International Airport

Model Calibration

The travel mode choice model was calibrated to match existing (2007) Amtrak ridership to/from Hampton Roads. The total ridership includes all destinations within the study area: destinations in Virginia, the Northeast Corridor and North Carolina (via transfer). The calibration process involved running the model using the time, cost, frequency and on-time performance characteristics of the existing 2007 Amtrak service, existing auto time/cost characteristics, existing air service characteristics, and 2007 population, employment and income data. The mode specific constants for rail were adjusted until the model output corresponded with the actual ridership data.