Evaluation of High-Speed Rail Options in the Macon-Atlanta-Greenville-Charlotte Rail Corridor

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1. INTRODUCTION

1.1 Background

The U.S. Department of Transportation (DOT), in conjunction with the Transportation Research Board (TRB), has undertaken research that indicates that high-speed ground transportation (HSGT) systems, including high speed rail (HSR), could be a competitive alternative to highway and domestic air travel in high-density travel markets and corridors in the United States, including the Boston-New York, New York to Washington, and San Francisco to Los Angeles corridors. TRB Special Report 233, "*In Pursuit of Speed, New Options for Intercity Passenger Transport,"* concludes that "HSGT systems could be an effective alternative in corridors where travel demand is increasing, but expanding capacity to reduce highway and airport congestion and delays is very difficult."

In its 1997 study "*High-Speed Ground Transportation for America,"* (commonly referred to as the Commercial Feasibility study or CFS), the FRA estimated the total costs and benefits of implementing a range of HSGT systems from incremental HSR with top speeds of 90 to 150 miles per hour (mph) ("IHSR," termed "Accelerail" in the 1997 report) to new HSR (with 175-200 mph top speeds) and maglev (up to 300 mph) in 11 illustrative corridors. The study identified the potential for diverted trips to competitive HSR and ground transportation services, especially for trips between 100 and 600 miles. The study found that HSGT's total benefits exceed total costs in many of the illustrative corridors.

The Volpe National Transportation Systems Center (Volpe Center) supported the FRA in the preparation of the CFS by making the ridership, cost, financial, environmental, and benefits estimates for the various combinations of technologies and corridors. The models and methods developed for the corridors studied in the CFS, including the analysis of the Southeast High Speed Rail Corridor (SEC) from Washington to Charlotte, will be applied to the case in which the SEC corridor is extended to South Carolina and Georgia.

This study corridor is part of the designated list of 11 HSR corridors authorized by ISTEA (Intermodal Surface Transportation Efficiency Act) in 1991 and supplemented by TEA-21 (Transportation Equity Act for the 21st Century) in 1998. This study will focus on the expanded SEC extending from Washington, D.C., south through the Carolinas and on to Georgia and Florida. The study area is a smaller section of the SEC starting in Charlotte, moving southwest through Greenville and Atlanta, and finally south to Macon. The potential rail corridors previously studied in the CFS did not include the portion from Charlotte, North Carolina, to Atlanta, Georgia, with an extension to Macon, Georgia. However, the North Carolina, South Carolina, and Georgia Departments of Transportation, with technical guidance from FRA, intend to analyze this route segment in a new study as an extension of the SEC (Washington to Charlotte) studied in the CFS by employing funding contained in the consolidated FY2004 appropriations, Public Law No. 108-199.

The Georgia Department of Transportation (GDOT), South Carolina Department of Transportation, and North Carolina Department of Transportation have signed a memorandum of understanding (MOU) to undertake an analysis of the Macon-Atlanta-Greenville-Charlotte segment under which GDOT will act as the lead state for the work. Federal funds for this purpose will be made available under this agreement to GDOT. The three state departments of transportation, through the MOU, have designated GDOT to oversee the agreement and conduct the project. FRA will serve in an advisory capacity to the states.

1.2 Purpose

This new study will assess the viability of a public-private partnership for rail development in this corridor extension where Government agencies invest in capital construction and maintenance of HSR infrastructure and a private, non-subsidized operator provides for train operations. This new business model for HSR was developed by the Southeastern Economic Alliance in its recent report. The train service to be studied for this corridor will have top speeds that are significantly faster than existing Amtrak service, might follow existing rail routes or employ a new straighter right-of-way, would likely have links at the end-point cities to connecting rail and air services, and would possibly incorporate through–train services to other non-corridor rail-served cities.

The Volpe Center will conduct market and economic studies to evaluate the feasibility and potential impact of various levels of HSGT in the Macon and Atlanta, Georgia, to Charlotte, North Carolina, HSR corridor. The Volpe Center will (1) recommend rail top speeds and technologies that balance potential ridership and revenues with infrastructure and operating costs; (2) forecast ridership over a at least a twenty-five year time horizon; (3) assess whether operating revenues might exceed operating costs and infrastructure maintenance costs; (4) compare this corridor's performance with similar rail corridors in other regions; and (5) determine other quantifiable economic impacts of HSR corridor investments.

1.3 Scope

The Volpe Center will build upon and extend the work previously completed by the Volpe Center for the FRA with respect to the SEC segment between Washington, D.C., and Charlotte, North Carolina, by accomplishing the tasks set forth below. Using the previous work as a paradigm, there will be seven main components to the analysis of intercity passenger rail in the Macon and Atlanta, Georgia, to Charlotte, North Carolina, corridor segment:

- Scenario Development
- Demand and Revenue Estimation
- Capital Cost Estimation

- Operating and Maintenance (O&M) Cost Estimation
- Corridor/Network Financial Analysis
- Societal Impacts Estimation

The following report documents an initial planning and feasibility study for intercity passenger rail service in the corridor from Charlotte, NC to Macon, GA. Because of the preliminary nature of this planning and feasibility study, all assumptions and results are subject to change as further and more detailed planning studies and design are completed. Further work including analysis of physical improvements required and financial and environmental analysis of the plan will be required before any major policy decisions can be made.

2. SCENARIO DEVELOPMENT

2.1 Introduction

The study's conclusions and recommendations will be determined by a set of plausible assumptions and well-designed scenarios defined at the beginning of the effort. The project initiators, the Georgia, South Carolina, and North Carolina Departments of Transportation, with their FRA technical advisors, have defined the initial parameters for the evaluation, including the end-point and some intermediate cities for the core corridor, at least one of several potential train speeds/technologies (i.e., top speed at least 125 mph) to be investigated, and the general outlines of the public-private partnership for rail development and operation in this corridor. The Volpe Center and GDOT will define more specific options/scenarios, make broad assumptions, and specify detailed inputs to the modeling process. Some of the variables and information that need to be specified are cities and airports served, station locations, existing rail lines and right-of-ways (ROW) used, passenger amenities provided, ownership assumptions, speed or trip time goals, and technologies used.

The major distinguishing characteristic of the scenarios will most likely be that each describes a different system concept (alignment and technology). The technology options defined in the FRA's CFS, i.e., IHSR with varying top speeds and new HSR, will be selected. For reasons of cost and connectivity with existing plans for the routes north of Charlotte, this study will only seek conventional modes of HSR transportation.

This study will evaluate the development and operating costs and potential passenger ridership associated with providing high-speed rail (HSR) service to the Macon, Atlanta, Greenville/Spartanburg, and Charlotte corridor. The train service to be studied for this corridor will have top speeds that are significantly faster than existing Amtrak service (with maximum speeds of 79 mph), might follow existing rail routes or employ a new straighter right-of-way, would likely have links at the end-point cities to connecting rail and air services, and would possibly incorporate through–train services to other non-corridor rail-served cities.

The study assessment will be based on a new business model concept for HSR that was developed by the Southeastern Economic Alliance in its recent report. This concept consists of a public-private partnership for rail development in this corridor where Government agencies invest in capital construction and maintenance of HSR infrastructure and a private, non-subsidized operator provides for train operations.

2.2 Technology Options

This section describes the six technology options for passenger rail vehicles proposed for evaluation of the planning study for the Southeast High Speed Rail project. The technology descriptions include: consist and individual vehicle characteristics (i.e. cost, weight, and seating), as well as an estimate for performance over a 365-mile (distance from Charlotte through Atlanta to Macon) non-stop route segment.

The major distinguishing characteristic of the scenarios is that each describes a different system concept (alignment and technology), with the technology options defined to be consistent with the ones defined in the Federal Railroad Administration's 1997 report, "*High-Speed Ground Transportation for America,"* (commonly referred to as the Commercial Feasibility study or CFS), i.e., incremental high-speed rail with varying top speeds and new high-speed rail. For reasons of cost and connectivity with existing plans for the routes north of Charlotte, this study will not investigate maglev options.

The six technology options considered fall into three basic categories. The first is Conventional Rail Transportation (CRT) with appropriate track improvements and improved signaling equipment at 90 mph. The 90 mph case would require all trains/track operating on the alignment to be equipped with upgraded signaling equipment. For the conventional 90 mph case, a tilting coach is assumed which is similar to tilting coaches as described below for high-speed rail.

High Speed Rail (HSR) covers the speed range from 110 mph to 150 mph with both electric power cars and fossil fueled locomotives. Increasing levels of change to the existing alignment will need to occur as the maximum speeds are increased. For the High Speed Rail 110-125 mph cases all coaches are assumed single level and tilting. The single level cars are some variation of an X2000, Talgo, or Acela style coach.

Finally, Very High Speed Rail (VHSR) is a 200 mph rail system, operating on a new alignment. The Very High Speed Rail 200 mph trainset is assumed to be similar to the European TGV consist. The trainset is made up of two end power cars and any number of articulated passenger vehicles.

Trainsets for each type of service would be optimized to provide frequent departures while minimizing the operations and maintenance costs. Typically this is a tradeoff between short and long trains. For this evaluation we have chosen consist configuration seating about 264 passengers as the baseline. This can be achieved using a single power engine and four passenger cars (1-4) or leading and trailing power cars and four center passenger cars (1-4-1) consist of single level equipment or a single power engine and three passenger cars (1-3) configuration using bi-level equipment. For the very high-speed case (200 mph), the baseline consist is the 1-6-1 (with leading and trailing power cars and six center passenger cars in married sets) seating 284.

The 90 mph and 110 mph cases were previously evaluated in the May 2004 report, "Macon-Charlotte Southeast High Speed Corridor Plan" by Georgia Rail Consultants This new evaluation will provide an opportunity to re-examine assumptions made in that study, e.g., concerning the degree to which track straightening along rail right-of-ways is feasible and cost-effective, in the context of (and consistent with) the assumptions and parameters made for high-speed and very high-speed rail options.

2.3 Alignment and Routing:

The alignment and routing alternatives for Southeast High-Speed Rail Charlotte to Macon corridor would have to be investigated in detail as part of subsequent studies. This exposition lays out some of the ground rules that will be used to match train technologies to feasible, least cost routes. The major tradeoff is between train speed and the cost (and availability) of right-of-way that is straight enough to support that train speed. The cost of ROW, even for the lowest-level improvement (reconstruction to speeds of 79-100 mph) will entail construction costs approaching $2,000,000/mile, plus the cost of new train control systems. Developmental costs include: right-of-way acquisition, track and supporting structures, train control, electrification, stations and maintenance facilities. Potential impacts on environmentally or historically sensitive areas and relocation of housing and other facilities are also major differential considerations.

2.4 Stations

This analysis will assume the same stations as used in the prior corridor study[1] for the basic set of scenarios. These are:

Macon,
Griffin,
Aviation Blvd/East Point (serving the Atlanta Airport),
Atlanta MMPT,
Gainesville,
Toccoa,
Clemson,
Greenville,
Spartanburg,
Gastonia, and
Charlotte.

In Atlanta, the HSR trains would use the MMPT (Multi-Modal Passenger Terminal), which is planned to host commuter rail and bus, intercity bus, and Amtrak trains. Direct connections to MARTA's Five Points station and local bus would also be available.

The station at either East Point or Aviation Boulevard would provide service to Hartsfield-Jackson International Airport. An East Point location would provide connections to the airport via MARTA's East Point station. An Aviation Boulevard location would be co-located with a planned multi-modal terminal with shuttle connections to the airport.

[1] Georgia Rail Consultants, *Macon-Charlotte Southeast High Speed Rail Corridor Plan*, Georgia Department of Transportation, South Carolina Department of Transportation, North Carolina Department of Transportation, Federal Railroad Administration, May 2004.

An additional set of scenarios will be considered which include stations at the Charlotte airport and in the northern suburbs (Atlanta Metro North). The report *Transportation Planning for the Richmond-Charlotte Railroad Corridor*[2] has specified locations for a new station in downtown Charlotte and a station serving the Charlotte airport.

2.5 Other Considerations

The demand for rail travel in the Charlotte to Macon corridor depends on an additional consideration that has to do with the interface with rail service north of Charlotte. In 1992, the United States Department of Transportation (USDOT) designated several high-speed corridors nationwide - including the Southeast Corridor from Washington, D.C. to Richmond, Raleigh, and Charlotte. In October 2002, North Carolina, Virginia, the Federal FHWA and FRA completed the vital first part of a two-part environmental study for the Washington, DC to Charlotte portion of the Southeast High Speed Rail Corridor (SEHSR). The study results from the Tier I Environmental Impact Study identified the preferred route and the overall project purpose and need. The Tier II study is expected to provide a detailed analysis on the impacts, including track location, station arrangement and detailed design. The project plans for the Southeast High Speed Rail Project proposes a fossil fuel locomotive with a top operating speed of 110 mph., with completion of the Tier II Environmental Impact Study by 2011, and construction anticipated in the 2015-2020 time frame.

For this study, we propose two possible cases. In terms of potential passenger demand generation, the least favorable case involves the situation where there will be no significant rail improvements between Charlotte and Washington DC, and that travelers with trip origins (destinations) in the Charlotte to Macon corridor will be required to transfer to existing Amtrak services for all destinations (origins) north of Charlotte. Existing Amtrak services consist of the Piedmont (1 round trip/day, Raleigh to Charlotte), the Carolinian (1 round trip/day, New York to Charlotte) and the Crescent (1 round trip/day, New York to New Orleans). The current average travel time from Charlotte to Washington DC on Amtrak is approximately 9.5 hours. The minimum transfer time will be assumed to be ½ hour, but because there are very few daily Amtrak frequencies, transfer times could be much longer.

The much more favorable case assumes connecting rail services envisioned in the Southeast High-Speed Rail studies are in place allowing higher speed travel from Charlotte to Washington and beyond. The Record of Decision for the Tier I Southeast High Speed Rail Project[3] was based on ridership estimates that assumed a 110 mph maximum speed, and 4 round trips/day, Charlotte to Washington, and an additional 4

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[2] Parsons Transportation Group, *Technical Monograph: Transportation Planning for the Richmond-Charlotte Railroad Corridor*, Federal Railroad Administration, January 2004.

[3] *The Record of Decision for the Tier I Southeast High Speed Rail Project,* Federal Railroad Administration, Federal Highway Administration, November 20, 2002.

round trips/day, Charlotte to Raleigh. The estimated end-to-end travel times for the improved rail alternatives studied range from 6 hours to 7.5 hours, which constitutes a 20 percent to 35 percent improvement over existing Amtrak service. This is in general agreement with the assumptions used in other studies of HSR in the Charlotte-Washington corridor[4]. In our most favorable case analysis of services north of Charlotte, we will assume the speed and frequency assumptions used in the Record of Decision, and incorporate through-train service connecting to Washington DC and, possibly, to some Northeast Corridor train destinations.

2.6 Scenario Definition

Thus each scenario defined by a technology/alignment assumption will be analyzed based on variations in the number of stations and the connecting rail services north of Charlotte.

The cases considered are as follows:

1 – All stations - Charlotte, NC, Charlotte International Airport, Gastonia, NC, Spartanburg, SC, Greenville Spartanburg International Airport (GSP), Greenville, SC, Clemson, SC, Toccoa, GA, Gainesville, GA North Atlanta Metro, MMPT Atlanta, Atlanta International Airport, Griffin, GA and Macon, GA

2 – All stations except GSP

3a – All stations except GSP, Toccoa and Griffin

3b – All stations except GSP, Toccoa and Griffin with Griffin bypass

4 – All stations except GSP, Toccoa, Atlanta North and Griffin

5 – All stations except Charlotte International Airport, GSP, Toccoa, Atlanta North, Griffin, and Atlanta International Airport

6 – Express option with stops at Charlotte, NC, Charlotte International Airport, GSP, Gainesville, GA, MMPT Atlanta, and Macon, GA.

The primary determinant in initial corridor location is the station stops. The table below lays out the seven station stop scenarios. Case 1 includes all stops and takes the preferred Decatur Route, along an abandoned Norfolk Southern (NS) route. The alternative is to follow the CSX freight alignment into the MMPT. This would require backing out of the

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[4]KPMG Peat Marwick LLP, Parsons Brinckerhoff Quade & Douglas, Inc., and Daniel Consultants, *Southeast High Speed Rail Market and Demand Study, Final Report*, North Carolina Department of Transportation, Virginia Department of Rail and Public Transportation, South Carolina Department of Transportation, Georgia Department of Transportation, Florida Department of Transportation, Federal Railroad Administration, August 1997.

Parsons Transportation Group, *Technical Monograph: Transportation Planning for the Richmond-Charlotte Railroad Corridor*, Federal Railroad Administration, January 2004.

Potential Improvements to the Washington-Richmond Railroad Corridor, National Railroad Passenger Corporation, May 1999

MMPT through a “Y” interchange to return to its southern travel. Case 3(a) and 3(b) are identical except that 3(a) proceeds through Griffin, Georgia, as in cases 1, and 2. Case 3(b) uses a new right-of-way corridor roughly tracking I-75 which avoids Griffin altogether. The I-75 option is used for all the other cases as shorter and less disruptive than roughly tracking the NS, primarily single track alignment, between Atlanta and Macon.

The technology considered will include:

> 90 and 110 mph diesel option: roughly follows existing freight railroad alignment with new single or double concrete tie track. Single track shares cross-overs with and trackage with the freight railroad, some high speed sidings, and the closing of most grade crossings.
>
> 125 mph diesel option: minimize track sharing with freight railroad, very few grade crossings allowed, significant new ROW required.
>
> 150 mph diesel option: no track sharing with freight except where speeds drop below 125 mph near stations, no grade crossings, mostly new ROW, all new double concrete ties track.
>
> 150 mph electric option: same as above except additional ROW required for electrification – poles to hang catenaries, substations and fencing.
>
> 200 mph electric only: Route as close to straight line between stations as possible, extra ROW for electrification necessary, no track sharing except where speeds drop below 125 mph entering and departing stations.

A more thorough explanation and description of the technology appears in Appendix G.

Table 2-1 Station Stop Options[1]

Station	Mileage	Case 1	Case 2	Case 3 (a)	Case 3 (b)	Case 4	Case 5	Case 6
Charlotte, NC	0	Stop	Stop	Stop	Stop	Stop	Stop	Stop
Charlotte Airport, NC	7	Stop	Stop	Stop	Stop	Stop	□	Stop
Gastonia, NC	22	Stop	Stop	Stop	Stop	Stop	Stop	□
Spartanburg, SC	77	Stop	Stop	Stop	Stop	Stop	Stop	□
Spart/Green Airport, SC	95	Stop	□	□	□	□	□	Stop
Greenville, SC	108	Stop	Stop	Stop	Stop	Stop	Stop	□
Clemson, SC	138	Stop	Stop	Stop	Stop	Stop	Stop	□
Toccoa, GA	171	Stop	Stop	□	□	□	□	□
Gainesville, GA	209	Stop	Stop	Stop	Stop	Stop	Stop	Stop
Atlanta North, GA	256	Stop	Stop	Stop	Stop	□	Stop	□
Atlanta, GA	262	Stop	Stop	Stop	Stop	Stop	Stop	Stop
Atlanta Airport, GA	272	Stop	Stop	Stop	Stop	Stop	□	Stop
Griffin, GA	305	Stop	Stop	□	I-75	□	□	□
Macon, GA	365	Stop	Stop	Stop	Stop	Stop	Stop	Stop

1-Stations are identified with "Stop" where stops are proposed, and arrows indicate the station is not included for that case.

The railed vehicle technology selected for study on the Macon-Atlanta-Greenville-Charlotte rail corridor encompasses operations with operating speeds of 90, 110, 125, 150, and 200 mph. For each scenario, an analysis of each running technology trip time performance (train performance calculation - TPC) and overall system operation provides estimates for optimal running times, intended schedules and expected performance for all services.

The trainset configurations are defined to evaluate different technology options with maximum operating speeds ranging from 90-200 mph. The existing track configuration is derived from freight railroad track charts, and modified routes are developed for each case studied. With this input, the TPC derives the general motion of a passenger consist from a simplified yet verifiable calculation using Newtonian laws of motion, train resistance, and motive propulsion power. Volpe is using a TPC originally developed by the University of Illinois in the mid-1970's, and more recently extensively modified by Volpe to specifically evaluate passenger rail service. The program has been validated, calibrated, and utilized in research by the Federal Railroad Administration Office of Research and Development.

The table below shows one-way trip times for various technology and station stop combinations.

Table 2-2 Summary One-Way Trip Times Including Pad/Dwell

	Case 1	Case 2	Case 3 (a)	Case 3 (b)	Case 4	Case 5	Case 6
Charlotte to Atlanta							
90 mph	3:51	3:48	3:44	3:44	3:41	3:40	3:31
110 mph	3:43	3:39	3:36	3:36	3:32	3:34	3:25
125 mph	2:55	2:50	2:46	2:46	2:43	2:43	2:31
150 mph	2:36	2:29	2:26	2:26	2:22	2:22	2:09
200 mph	2:22	2:13	2:08	2:08	2:03	2:04	1:46
Charlotte to Macon							
90 mph	5:29	5:26	5:20	5:00	5:17	5:14	5:07
110 mph	5:21	5:17	5:11	4:43	5:06	5:06	4:58
125 mph	4:05	4:00	3:51	3:45	3:47	3:44	3:36
150 mph	3:36	3:31	3:23	3:17	3:18	3:15	3:06
200 mph	3:16	3:07	2:57	2:51	2:51	2:48	2:35

3. DEMAND AND REVENUE ESTIMATION

3.1 Introduction

One of the requirements of this study is to forecast ridership and revenue impacts of new or improved service in the Macon-Atlanta-Charlotte high-speed rail (HSR) corridor. The analysis is mainly done at the level of individual city pair markets, but results are aggregated to produce summary statistics at the corridor level. The major steps in the process of estimating demand using the Volpe/CFS (Commercial Feasibility Study) model are indicated below:

Estimate the number of base year trips for the air, auto, bus and rail modes.

Produce trip forecasts for each of the modes and future years of analysis.

Develop demand model inputs, or modal characteristics for each of the existing modes and for the new or improved service.

Estimate the diverted trips from each mode to the new or improved service and the induced trips due to service improvement.

Estimate ancillary revenues expected from operating the rail system.

3.2 Develop Estimates of Base Year Trips

3.2.1 Specify Zonal System

The CFS model's zonal system is based on Metropolitan Statistical Areas (MSAs). In large MSAs, containing more than one station, MSAs are subdivided into "partials" which are counties. The approach used in this study represents a compromise approach: county based in the study area; MSA based north of Charlotte; counties split in the study area in order to isolate airports and ensure that each station is in a unique zone; all results in study area are at the partial-to-partial level; results for areas north of Charlotte are at the partial-to-MSA level.

3.2.2 Develop Base Year Trip Tables for Auto, Air, Rail, and Bus for the Common Base Year

The CFS model requires the total number of trips (both ways) by auto, bus and conventional rail on a partial to partial basis and trips by air on a MSA to MSA basis for a common base year.

The base year for defining trips was the latest common year for which origin-to-destination (O/D) data were available for air, rail, bus, and auto. This was 2003. Amtrak station-to-station ridership data for 2003 was available at Volpe. Unfortunately it was not possible to obtain more recent data for use in this study.

Rail - Amtrak station to station ridership data were available for 2003 for the Crescent, Carolinian and Piedmont. The data are for both directions.

Air - Air traffic data for the year 2003 was obtained from DOT's Office of Aviation Analysis' Consumer Airfare Report. This lists the number of one-way passenger trips per day, the nonstop distance, the average market fare, and identifies the airlines with the largest market share and the lowest average fare; market share and average fares are provided for both airlines.[1]

Air data is used at the MSA to MSA basis and not at a partial to partial basis.

Missing data (primarily from Macon) was obtained from Data Base Products O&D plus Origin & Destination Survey of Airline Passenger Traffic.

Bus - Bus OD data were estimated using the techniques used in the CFS (and GRP) studies, i.e., determining the number of passengers as a product of load factor and scheduled frequency. Annual number of passengers on a given route, e.g., Atlanta to Charlotte, were estimated as 365 days times the number of buses per day serving that OD pair times the number of seats per bus (45) times a 50% load factor. Bus size and load factor were as assumed in the CFS. The percent of passengers traveling between various intermediate points on this route say A-B, was estimated as g(AB)/Sum(g). The factor g(AB) was calculated as (population (A) times population(B)) divided by distance^2. This resulted in the distribution of passenger trips between all possible combinations of city pairs within the bus route. The number of passengers traveling between each city pair was first estimated by applying the distribution against 22.5 passengers. This assumed that 22.5 passengers in total traveled somewhere between the route's origin and destination. This resulted in an under estimate of trips. These numbers were inflated in order to account for the assumption that on average there were 22.5 persons on each route segment. The number of passengers traveling from the route origin to the all destinations was adjusted so that to number of passengers on the first route segment would equal 22.5. The number of passengers on all downstream segments was inflated accordingly. Segment to segment loads were checked to identify the segment with the maximum load. If this segment exceeded 45 passengers then the load on this segment was set to 45 and all segment loads were adjusted downward accordingly. This process resulted in the final OD passenger volumes for the route.

Twenty two routes were identified that provided service in the corridor and to cities north of Charlotte. Total ridership on each OD pair was calculated as the sum of the ridership on the individual routes serving that OD pair. Current (2006) schedules were obtained from http://www.greyhound.com/ which provided the stopping patterns for each bus "route". Distances were obtained from http://www.mapquest.com/ .

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[1] http://ostpxweb.ost.dot.gov/aviation/X-50%20Role_files/consumerairfarereport.htm

Auto - Auto data were available for select city pairs from prior studies (Southeast HSR Market and Demand Study, Georgia Rail Plan). However, this data was from the mid to late nineties and had to be adjusted to the selected base year by means of growth factors. Missing O/D data were estimated using the models and approaches used in the CFS, and the Georgia Rail Plan.

The report *Southeast High Speed Rail Market and Demand Study* [2] provides 1995 trips by mode for certain city pairs of interest. These data were factored up to represent traffic flows in the selected base year. The markets of interest included Atlanta to Greenville, Charlotte, Greensboro, Raleigh, Richmond, and Washington; Greenville to Charlotte, Greensboro, Raleigh, Richmond, and Washington; and Charlotte to Greensboro, Raleigh, Richmond, and Washington.

Another report provided by GA DOT provided additional information needed to define a base year trip table[3]. The traffic volumes for 1995 are based on a survey of travelers for the most part. However, for those O/D pairs where no survey data were available the 1995 numbers were estimated using a direct demand model described in a companion report (Intercity Rail Plan, Technical Reports, Volume II, Ridership Report).

This was the source of auto trip data for Macon to Griffin, Atlanta, Gainesville/Toccoa, and Greenville/Spartanburg; Griffin to Atlanta, Gainesville/Toccoa, and Greenville/Spartanburg: Atlanta to Gainesville/Toccoa, and Greenville/Spartanburg; and Gainesville/Toccoa, to Greenville/Spartanburg.

The 1995 OD data were factored up to 2003 by the following process. First 1995 city to city flows were adjusted to account for differences in "city" definitions between the earlier studies and the current study. OD trips were assumed to be proportional to the OD population-per capita income product. City to city flows were allocated to partials using the approach used in the CFS.[4] Finally 1995 flows were converted to 2003 (the base year) using partial to partial growth factors derived from the Volpe Inter-Regional Trip Model. These growth factors were checked against factors derived from traffic count data on I75 and I85 provided by GADOT and factors derived from VMT on rural interstate and rural

[2] KPMG Peat Marwick LLP, Parsons Brinckerhoff Quade & Douglas, Inc., and Daniel Consultants, *Southeast High Speed Rail Market and Demand Study, Final Report*, North Carolina Department of Transportation, Virginia Department of Rail and Public Transportation, South Carolina Department of Transportation, Georgia Department of Transportation, Florida Department of Transportation, Federal Railroad Administration, August 1997.

[3] *Intercity Rail Plan, Phase I Report,* LS Transit Systems, Inc., Prepared for Georgia Department of Transportation, May, 1996.

[4] Under this approach, each city is broken down into pieces (called partials) and auto trips are estimated between the pieces of each city. A distribution of trips is created from these results. This distribution is then applied to the total number of trips between the two cities in order to allocate the total number of trips to the various partial to partial pairs.

principal arterial highways traffic as reported in FHWA's *Highway Statistics.* Growth factors derived from all sources were in basic agreement.[5]

Missing auto OD data was estimated using the Volpe Inter-regional auto Trip Model[6]. The model estimates one way auto trips between city pairs as a function of population times average per capita income of the origin, population times average per capita income of the destination, road mile distance between city pairs, rail frequencies for the city pair, and dummy variables for city pairs including New York City, and for cities which are major tourist attractions (e.g., Las Vegas and Orlando).[7] Road mile distance between city pairs was obtained from Mapquest.com. Population estimates for 2003 were obtained from the Census Bureau. (http://www.census.gov/popest/datasets.html) For those zones involving tract data, the 2003 tract population was estimated as the 2000 tract population times the growth for the county containing the tract over the period 2000 to 2003. Income per capita estimates for 2003 at the county level were obtained from Woods & Poole. Population and income data for 1995 were from Woods & Poole.

3.3 Develop Forecasts of Future Trips

The forecast period selected by the study team is consistent with prior studies, legislative intent and available data. It covers the period 2015 to 2040. The study team felt that 2015 was the earliest date the system could be in operation. Since forecasts beyond 2030 were not available, projections for the 2030 to 2040 period were based on extrapolation of trends up to 2030.

City/zonal pairs not having service by air, bus, or rail in the base year do not have service (zero trips) by that mode in the forecast years. In addition certain short distance partial to partial pairs have zero auto trips because the Volpe/CFS "intercity" model was not calibrated for use in those cases involving "intracity" auto trips.

3.3.1 Obtain Projections of Socioeconomic Variables for the Forecast Period

A consensus set of socioeconomic projections (population, employment, income) were used based on data from commercial firms (Woods & Poole), the Census Bureau, and

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5 For example the average growth factor for I75 was 1.44 (an average annual growth of 5.47%/year) and for I85 1.35 (an average annual growth of 4.41%/year). The average growth factor for rural interstates in Georgia was 1.36 and in South Carolina it was1.32. The average Volpe model growth factor was 1.41.

6 Brodesky, Robert P., *INTER-REGIONAL TRIP MODEL, Methodology, Assumptions, and Application,* The Volpe Center, U.S. Department of Transportation, Cambridge, MA. Note that model results must be multiplied by 1,000 by 2 in order to be comparable to all other modal trip inputs to the CFS model.

7 Other direct demand models were considered, but not used because of extensive input LOS data requirements, the need to recalibrate the model against actual traffic count data, or the ability to predict only a change in travel between two points in time rather than an absolute value. These included the models used in the Georgia Rail Plan Study, the California High Speed Rail Study, and the original Southeast Corridor High Speed Rail Study.

state agencies. The data needed for use in the CFS model include population, per capita income, household income (and or household size), and employment. The socioeconomic data are used in models that forecast future auto traffic.

All of the required variables are available from Woods & Poole[8]. Alternative population projections were most widely available. The Woods & Poole data were compared to projections from the Census Bureau at the state level and to county level projections developed by Georgia, North Carolina and South Carolina. At the state level, the Woods & Poole data project a slightly higher rate of growth than the Census projections with the exception of North Carolina. At the county level the Woods & Poole projections are comparable to those developed by the individual states, but not consistent. In some cases Woods & Poole is higher, sometimes lower and other times nearly identical.

3.3.2 Develop Traffic Projections for the Analysis Period

Air - FAA's *Terminal Area Forecasts*[9] provide forecasts of the growth in enplanements for individual airports. The hard copy version only provides year by year enplanement data by FAA region and a national total. Forecasts for individual airports can be obtained by querying FAA's on line data base. http://www.apo.data.faa.gov/main/taf.asp Growth factors for each market were estimated as the average of Terminal Area Forecasts for each airport in the pair. These growth rates vary from 2.3 % (Macon-Atlanta) to 7.4 % (Greenville-DC).

TAF based growth factors were used to produce the forecast air trips. FAA forecasts were used as a check on our projections of air traffic growth.[10] The intermediate forecasts provide estimates of growth in enplanements, revenue passenger miles and yield on a national level. The long range forecasts only provide a national level estimate of the growth in enplanements and real yield over the forecast period. Declining real yields are projected over the forecast period. Neither set of forecasts provides any information on growth in individual markets. Note that the FAA forecasts in comparison to actual tend toward the high side. The intermediate forecast is for an average annual growth of 3.4% in revenue passenger miles and 2.9 % in enplanements for domestic carriers for the period 2005-2017. The long range forecast is for an average annual growth of 3.0 % in enplanements for domestic mainline carriers and 3.4 % for regional/commuters for the period 2017-2030.

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8 *2006 Desktop Data Files,* Woods & Poole Econometrics, Washington, D.C., January 2006.

9 *Terminal Area Forecast Summary, Fiscal Years 2005-2025*, FAA-APO-06-1, Federal Aviation Administration, U.S. Department of Transportation, March 2006.

10 *FAA Long-Range Aerospace Forecasts Fiscal Years 2020, 2025, and 20*30, July 2005.
FAA Aerospace Forecasts Fiscal Years 2006-2017, Office of Policy and Plans, Federal Aviation Administration, U.S. Department of Transportation.

Auto- Auto flows for the forecast years were estimated using partial to partial growth factors derived from the Volpe Inter-Regional Trip Model.[11] The auto trip growth factor was calculated as Forecast Trips (in the forecast year) divided by Forecast Trips in 2003 (the base year). Road mile distance between city pairs was obtained from Mapquest.com. Total personal income estimates for 2003 and projections 2015 to 2030 at the county level were obtained from Woods & Poole. Projections for 2031 to 2040 were extrapolated. For those zones involving tract data, the tract income as a percentage of the total county income was assumed to be proportional to the 2003 tract population.

The auto growth factors when converted to an average annual percentage growth exceed the statewide 2% growth in VMT of the Georgia Statewide Transportation Plan over the period 2003-2035. The CFS based factors result in growth of 3 to 4.2% per year in the Atlanta –Macon corridor over the period 2003-2035, and 3.5 to 4.8% per year in the Atlanta –Gainesville corridor. However this growth compares reasonably well to the historical growth in ADT measured on I 85 (4.4 % per year) and I 75 (5.5% per year).

Bus - As in the CFS, bus growth factors are assumed to be the same as those for auto for a given city pair.

Rail - As in the CFS, rail growth factors are assumed to equal the average of the air and auto growth factors for a given city pair.

3.4 Develop Demand Model Inputs

The diversion model requires level of service data for each mode under consideration including line haul time, access/egress time, terminal time, wait time (frequency), transfer time, line haul cost, and access/egress cost. The modes considered include air, auto, rail, bus, and HSR. All data items are required by trip purpose (business/non-business).

The sources and use of the Level of Service (LOS) data used in the CFS model is described in general terms in the document *Volpe Center Intercity Passenger Analysis System, Demand and Revenue Estimation*[12]. Details related to the LOS inputs are provided in the Appendix to this report.

Air fare, frequency, and line haul times were obtained from the Official Airline Guide (OAG), and the same sources used to obtain the base year trip data, DOT's Office of Aviation Analysis' *Consumer Airfare Report*. This is the source of our base year (2003)

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[11] Brodesky, Robert P., *INTER-REGIONAL TRIP MODEL, Methodology, Assumptions, and Application,* The Volpe Center, U.S. Department of Transportation, Cambridge, MA.

[12] *Volpe Center Intercity Passenger Analysis System, Demand and Revenue Estimation,* Volpe National Transportation Systems Center, Cambridge, MA, June 1996.

fare data. Average fares are average prices paid by all fare paying passengers. They therefore cover first class fares paid to carriers offering such service but do not cover free tickets, such as those awarded by carriers offering frequent flyer programs.

The Air Business Fare to Air Non-Business Fare Ratio is based on next day and 30 day advance purchase fares from ORBITZ.com for city pairs in the study corridor. The value 1.81 is the average. The corresponding ratios for bus and rail were based on data from Greyhound.com and Amtrak.com.

Costs and fares were converted from the year of the specific source to 1992 dollars for use in the model and to a common year for presentation purposes.

Hard copy OAG[13] for 2003 was the source of frequency, and line haul time data for both direct and connect flights by city pair. Connect flights were those "published" in the OAG. These are not necessarily all possible connect flights. Connect flights had to be created for city pairs having traffic indicated in the OST data but not having flights in the OAG. Connect flights were constructed using the approach of the OAG, that is find flights from the origin city to an intermediate airport, allow for the minimum connect time at the intermediate airport, and then find a flight to the final destination. This approach was used for the city pairs Macon to Greenville, Charlotte, Greensboro, Raleigh, Richmond, Washington and NEC (New York), and Greenville to Greensboro and Richmond.

Air traffic data is available from Data Base Products, Inc. These data provide total passengers, average fare, average coupons, average length of haul, and coupon yield for specified markets. This was used as a check on the OAG for average coupons per market, i.e., the direct/connect flight split. Times are the coupon weighted average of direct/connect flights in a given market.

Published times were adjusted to reflect delays reported in the BTS on-time performance report.[14]

Rail fare, frequency, and line haul times were obtained from Amtrak timetables and their web site.

Bus fare, frequency, and line haul times were obtained from Greyhound.com.

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[13] *OAG Flight Guide – North America,* OAG Worldwide, Inc., Downers Grove, IL, Vol. 29, No. 17, June 1, 2003.

[14] This is the ASQP (Airline Service Quality Performance) data. The measure used was "Arrival Delay – The difference between the scheduled arrival time and the actual arrival time at the destination airport gate."
http://www.bts.gov/xml/ontimesummarystatistics/src/ddisp/OntimeSummarySelect.xml?tname=OntimeSummaryBothData

Common carrier terminal times, transfer times and access/egress times and costs were obtained from CFS data files.

Auto times were obtained from MapQuest, and CFS data files.

Auto operating costs were obtained from AAA (American Automobile Association).[15] They give operating cost of 15.1 cents/mile (tires, maintenance, and gas) and full costs of 52.2 cents per mile. The later is the composite national average and includes operating costs plus insurance, license, taxes, registration, depreciation and finance charges.

HSR line haul times were obtained from Volpe's Train Performance Calculator (TPC) results. Results are available for 8 cases (variations in stops and alignments) and 5 top speeds within each case (90, 110, 125, 150, and 200 mph).

Frequency was assumed, i.e., a given in the scenario definition. As a starting point we assumed 6 trains per day each way.

For this study HSR fares were based on Amtrak yield (2003 dollars). The average yield from the Piedmont and Carolinian was used ($.209/mile). The average fare for specific city-pairs was computed as yield times distance. Distances were obtained from the TPC model.

3.5 Estimate Diverted Trips/Induced Trips

The diversion from existing modes to a new or improved rail system is determined for existing market segments. The intercity travel market was broken into several mutually exclusive market segments. Market segments were defined by mode (air, auto, existing rail, and intercity bus) and by trip purpose (business and non-business). In addition, submarkets segments were established that relate to auto travelers requirements for automobiles along the route or at the destination city.[16]

The diversion models are generally applied to a city-to-city level of aggregation, except in major metropolitan areas that are broken into smaller subdivisions.

The demand forecasting methodology employs a logit-type diversion (mode split) model structure that operates on each sub-market separately. The general form of the diversion model is:

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[15] http://www.aaapublicaffairs.com/Main/Default.asp?CategoryID=3&SubCategoryID=9&ContentID=23

[16] *Volpe Center Intercity Passenger Analysis System – Capabilities Statement,* Volpe National Systems Center, U.S. Department of Transportation , Cambridge, MA, June 1996.

$$\% \text{ Divert} = \frac{e^{U_{hsr}}}{e^{U_{hsr}} + e^{U_{exist\ mode}}}$$

Where, U_{hsr} is the utility of HSR travel, $U_{exist\ mode}$ is the utility of the existing mode of travel, and e is the exponential operator. The utility of each of the travel choices is defined as a linear function of a typical traveler's line-haul travel time and cost, access/egress travel time and cost, wait time (frequency) and modal preference.

Separate binary choice (diversion) models, each comparing the attributes of a new or improved technology and one of the existing modes or sub-modes of travel, are applied to each market segment. The diversion model approach uses all of the data about travelers' current choices of transportation mode and trip purpose and their stated preferences for new or improved services based on the characteristics of each travel option. The approach provides complete flexibility in forecasting the wide variations in traveler preferences to substitute the new or improved mode for the current available modes of intercity travel.

The final step in the travel demand estimation procedure involves the estimation of induced demand. Induced demand comes about when the introduction of new or improved rail service leads to the generation of entirely new trips or the increase in frequency of existing trips. This new trip making should be proportional to the increase in level-of-service for intercity travel in the entire market. The approach used in estimating induced trips is described in the Appendix.

The CFS model and most intercity demand models do not produce reliable/credible results at distances of less than 50 miles. Trips of less than 50 miles are not generally considered as "intercity" trips. An alternative approach to estimating HSR demand was used for these cases. The short distance trips from the airport stations to Atlanta, Charlotte, Greenville and Spartanburg are estimated using a separate technique. The approach used in estimating airport trips is described in the Appendix.

3.6 Estimate Ancillary Revenues

Ancillary revenues are from sources other than passenger tickets. Examples include on board and station advertising, station concessions, on board food service, etc. A review of the literature surfaced a number of prior intercity rail studies that considered ancillary revenues in their analyses.

The prior studies all gave examples of ancillary revenue sources that they included or considered. However, the prior studies generally did not indicate a method or rationale for estimating ancillary revenues. The approach presented was that of estimating ancillary revenue as some percentage of passenger revenue. It was not clear whether the percentage indicated was based on some unreported analysis, historical data, or purely a judgment call. The study results are presented in the Appendix.

For this study we will assume that ancillary revenues are an additional 5% of passenger revenue derived from advertising, on-board beverage service, on-board phone, fax and entertainment, station concessions, and small package express services.

Ancillary revenues are included in the comparison with O&M costs in estimating annual operating profit/loss.

3.7 Summary Base Case Results

The tables below indicate the estimated ridership, revenue, and passenger-miles for the seven cases considered for the Georgia HSR Study. These cases are as follows:

> Case 1 includes all fourteen stations - Charlotte, NC, Charlotte International Airport, Gastonia, NC, Spartanburg, SC, Greenville Spartanburg International Airport (GSP), Greenville, SC, Clemson, SC, Toccoa, GA, Gainesville, GA North Atlanta Metro, MMPT Atlanta, Atlanta International Airport, Griffin, GA and Macon, GA.
>
> Case 2 includes all stations with the exception of the Greenville Spartanburg International Airport (GSP) for a total of thirteen stations.
>
> Case 3a includes all stations with the exception of the Greenville Spartanburg International Airport (GSP), Toccoa and Griffin for a total of eleven stations.
>
> Case 3b is identical to Case 3a except for a reduced line haul time from Macon to the Atlanta airport because of a different alignment.
>
> Case 4 includes all stations with the exception of the Greenville Spartanburg International Airport (GSP), Toccoa, Atlanta North (Doraville) and Griffin for a total of ten stations.
>
> Case 5 includes all stations with the exception of the Charlotte Airport (CLT), the Greenville Spartanburg International Airport (GSP), Toccoa, the Atlanta Airport (ATL) and Griffin for a total of nine stations.
>
> Case 6 includes the minimum number of stations (seven) - Charlotte, NC, Charlotte International Airport, Greenville Spartanburg International Airport (GSP), Gainesville, GA, MMPT Atlanta, Atlanta International Airport, and Macon, GA.

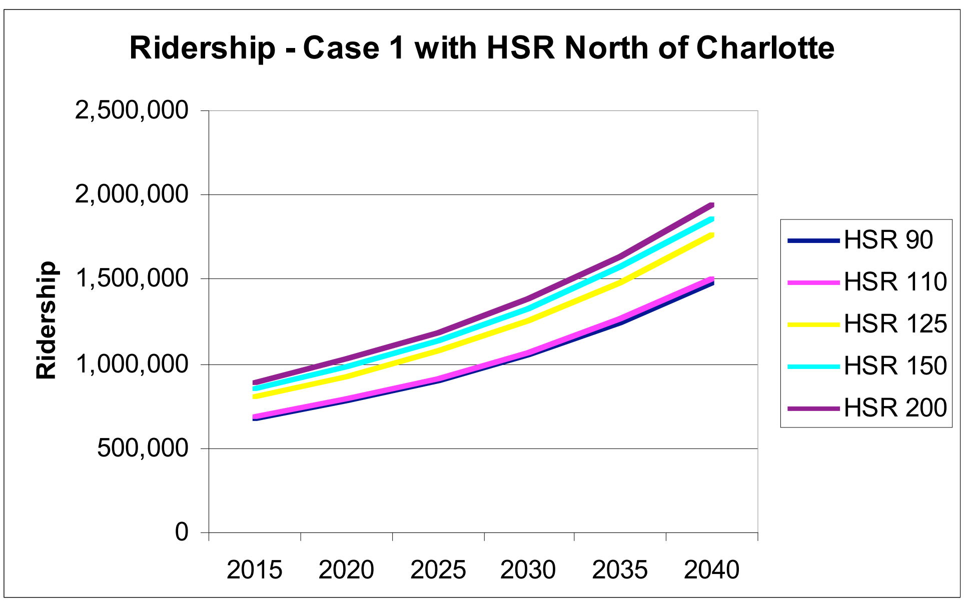
Estimates are presented for five speed/technology assumptions and for the situations where the proposed HSR service north of Charlotte is running and where the proposed HSR service north of Charlotte is not running and existing Amtrak services must be used. The results are shown for 2025 in order to allow comparison with the previous corridor study, which used 2025 as its forecast year[17]. Summary results for 2015, 2020, 2030, 2035 and 2040 are presented in the Appendix. Results are available for 420 individual "cases".

The revenues indicated are estimated fare box revenues only and do not include ancillary revenues.

The current estimates do not include diversions from auto for city pairs less than 50 miles apart. The CFS model and most intercity demand models do not produce consistently reliable/credible results at distances of less than 50 - 75 miles. Trips of shorter distances are not generally considered as "intercity" trips. However, the short distance trips from the airport stations to Atlanta, Charlotte, Greenville and Spartanburg were estimated using a separate technique and are included in the current estimates.

As indicated in the Tables below and in the Figure 3-1, ridership increases with increasing speed within any given case. Reduced line haul times make the HSR alternative more attractive all other things being equal.

Figure 3-1

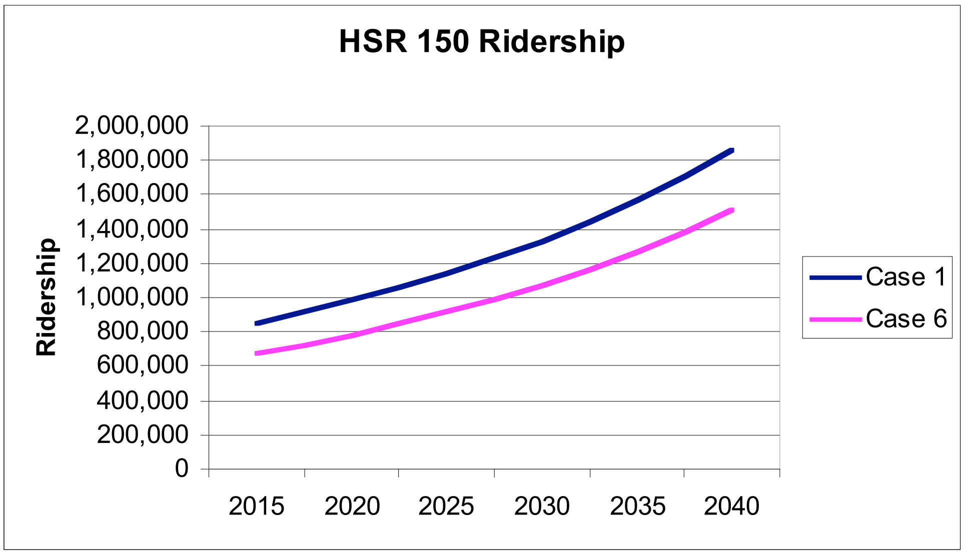


Ridership decreases as stations are eliminated within any given technology assumption. In general, eliminating a stop and decreasing line haul time do not make up for the fact that travelers who would have used that station either travel farther to an alternative station or do not make the trip on HSR at all. The CFS model places a greater value on out-of-vehicle time than on in-vehicle time. The relatively minor line haul time savings

[17] *Macon-Charlotte Southeast High Speed Rail Corridor Plan,* prepared for Georgia Department of Transportation, South Carolina Department of Transportation, North Carolina Department of Transportation, and Federal Railroad Administration, Georgia Rail Consultants, May 2004.

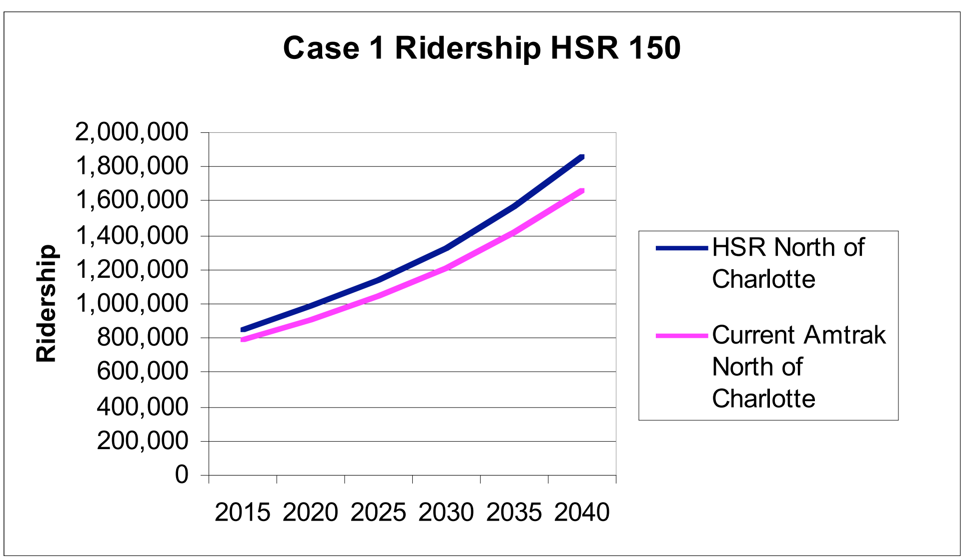
achieved by dropping a given station do not attract enough new riders to make up for those who abandon HSR because of the increased access/egress time and cost. While the net loss in ridership due to station elimination decreases as speed increases it still results in a net loss in ridership. Figure 3-2 illustrates the variation in ridership between the fourteen station case and the six station case.

Figure 3-2



The existence of an attractive HSR service north of Charlotte attracts considerable additional ridership within the Macon-Charlotte study corridor, on the order of 100,000 trips per year.

Figure 3-3



Also ridership increases with the passage of time due to growth in population, income and travel in the corridor. For example annual ridership for the 150 mph technology in case 1 with HSR north of Charlotte is projected to increase from 852,000 in 2015 to 1,860,000 in 2040.

The ridership estimates shown here are comparable to those presented in the report *Macon-Charlotte Southeast High Speed Rail Corridor Plan*.

The prior study "estimated" 902,000 trips per year at 90 mph and 930,000 trips at 110 mph. Revenues were estimated at $33.3 million for the 90 mph case and $34.6 million for the 110 mph case. The Case 1 estimates are 904,000 trips per year at 90 mph and 918,000 trips per year at 110 mph, with corresponding revenues of $20.2 million and $20.8 million.

Their estimates were for 2025 with 6 trains per day each way and assumed HSR north of Charlotte. This is consistent with our assumptions.

The station stops are the same except that we include stops at the Charlotte and Greenville/Spartanburg airports and a north suburban station. However line haul times are identical in the 90 mph case (5 hr 29 min Macon to Charlotte) and only 4 minutes different in the 110 mph case (our 5 hr 21 min vs. their 5 hr 25 min). Their fares ranged from 20 to 27 cents per mile in 2003 dollars depending on the market, while our fares (based on the yield for the Piedmont/Carolinian) are 22 cents per mile in 2003 dollars.

A sensitivity analysis was performed on four variables; HSR frequency, auto travel time, auto travel cost, and HSR fare. Additional analyses were performed in order to identify a fare which would maximize profit or minimize loss as well as maximize revenue. The results of these analyses are presented in the Appendix.

Table 3-1 2025 Annual One Way Trips with Current Amtrak North of Charlotte

Case	Total Annual HSR 90 Trips	Total Annual HSR 110 Trips	Total Annual HSR 125 Trips	Total Annual HSR 150 Trips	Total Annual HSR 200 Trips
1	822,100	834,600	985,200	1,045,000	1,090,000
2	811,000	824,900	976,400	1,038,000	1,086,000
3a	753,300	763,500	878,600	925,100	966,700
3b	778,200	800,500	889,800	935,000	980,200
4	720,400	731,900	847,100	890,700	933,800
5	443,300	452,900	557,500	601,100	644,100
6	657,500	667,800	776,300	818,400	859,700

Table 3-2 2025 Annual One Way Trips with HSR North of Charlotte

Case	Total Annual HSR 90 Trips	Total Annual HSR 110 Trips	Total Annual HSR 125 Trips	Total Annual HSR 150 Trips	Total Annual HSR 200 Trips
1	904,500	918,100	1,077,000	1,142,000	1,190,000
2	892,700	907,800	1,068,000	1,134,000	1,187,000
3a	833,700	845,100	968,900	1,020,000	1,066,000
3b	858,700	882,100	980,100	1,030,000	1,080,000
4	799,900	812,600	936,000	983,900	1,031,000
5	523,200	533,600	646,800	694,900	742,300
6	737,400	748,500	866,200	913,300	960,800

Table 3-3 2025 Annual Revenues (2006 dollars) with Current Amtrak North of Charlotte

Case	Total Annual HSR 90 Revenues	Total Annual HSR 110 Revenues	Total Annual HSR 125 Revenues	Total Annual HSR 150 Revenues	Total Annual HSR 200 Revenues
1	$16,470,000	$17,030,000	$21,590,000	$23,360,000	$24,720,000
2	$16,500,000	$17,130,000	$21,750,000	$23,600,000	$25,080,000
3a	$14,140,000	$14,710,000	$19,010,000	$20,700,000	$22,230,000
3b	$14,700,000	$15,540,000	$19,260,000	$20,920,000	$22,530,000
4	$13,350,000	$13,970,000	$18,150,000	$19,870,000	$21,480,000
5	$12,080,000	$12,500,000	$16,730,000	$18,490,000	$20,110,000
6	$12,730,000	$13,210,000	$17,490,000	$19,280,000	$21,030,000

Table 3-4 2025 Annual Revenues (2006 dollars) with HSR North of Charlotte

Case	Total Annual HSR 90 Revenues	Total Annual HSR 110 Revenues	Total Annual HSR 125 Revenues	Total Annual HSR 150 Revenues	Total Annual HSR 200 Revenues
1	$20,170,000	$20,780,000	$25,740,000	$27,710,000	$29,240,000
2	$20,190,000	$20,880,000	$25,910,000	$28,000,000	$29,690,000
3a	$17,780,000	$18,400,000	$23,100,000	$25,010,000	$26,760,000
3b	$18,340,000	$19,230,000	$23,350,000	$25,230,000	$27,060,000
4	$16,940,000	$17,610,000	$22,160,000	$24,090,000	$25,920,000
5	$15,670,000	$16,140,000	$20,750,000	$22,720,000	$24,550,000
6	$16,260,000	$16,780,000	$21,490,000	$23,510,000	$25,560,000

Table 3-5 2025 Annual Passenger Miles with Current Amtrak North of Charlotte

Case	Total Annual HSR 90 Pax-Miles	Total Annual HSR 110 Pax-Miles	Total Annual HSR 125 Pax-Miles	Total Annual HSR 150 Pax-Miles	Total Annual HSR 200 Pax-Miles
1	68,430,000	70,590,000	88,760,000	95,830,000	101,200,000
2	68,460,000	70,900,000	89,280,000	96,660,000	102,500,000
3a	58,340,000	60,550,000	77,520,000	84,200,000	90,260,000
3b	60,870,000	64,300,000	78,640,000	85,180,000	91,610,000
4	55,120,000	57,530,000	73,980,000	80,730,000	87,090,000
5	49,790,000	51,470,000	68,220,000	75,080,000	81,510,000
6	50,890,000	52,770,000	69,540,000	76,450,000	83,290,000

Table 3-6 2025 Annual Passenger Miles with HSR North of Charlotte

Case	Total Annual HSR 90 Pax-Miles	Total Annual HSR 110 Pax-Miles	Total Annual HSR 125 Pax-Miles	Total Annual HSR 150 Pax-Miles	Total Annual HSR 200 Pax-Miles
1	85,490,000	87,900,000	107,900,000	116,000,000	122,200,000
2	85,490,000	88,210,000	108,500,000	117,000,000	123,900,000
3a	75,110,000	77,570,000	96,440,000	104,100,000	111,300,000
3b	77,640,000	81,320,000	97,560,000	105,100,000	112,600,000
4	71,650,000	74,320,000	92,520,000	100,300,000	107,700,000
5	66,370,000	68,240,000	86,810,000	94,670,000	102,100,000
6	67,180,000	69,240,000	88,020,000	96,050,000	104,300,000

3.8 Capacity Checks

Demand estimates were prepared under the assumption that HSR service would be provided by six trains per day each way. A check was performed in order to determine whether or not these trains could in fact carry the predicted number of passengers.

For each case, and technology total annual ridership on each segment (e.g., Macon to Griffin) of the line was determined. This was done for the forecast years 2015 and 2040. The annual number of available seats was determined as the product of seats per train times the number of trains per year both ways. For the HSR 90, 110, 125, and 150 technologies the analysis assumed four car trains having a total of 264 sets per train. For the HSR 200 technology six car trains with 284 seats per train were assumed. The load factor was determined for each segment for each case, technology and forecast year considered. Those situations where the load factor exceeded one were identified. An additional car was added to each train set and the load factor recalculated until a load factor of less than one was achieved.

The only cases in which the load factor exceeded one on any given segment of the line were those involving the revenue maximizing fares for the situation where the complementary HSR service was in place north of Charlotte for the forecast year 2040. In these cases it was still possible to accommodate forecast traffic in 2035 using the train set configuration assumed initially. Adding one additional car per train in these cases would reduce the load factor to less than one.

3.9 Train Set Requirements

Trainset requirements were estimated for each of the technology cases (90 – 200 mph) and for the maximum and minimum run times cases based on number of stations.

Run times were from the TPC analysis for each technology/number of stations cases. A turn around time of 2 hours was assumed based on prior Volpe work for the OIG on Amtrak restructuring analysis. It was further assumed that trains would not operate in the "middle of the night" and that there would be no dead heading. Trains operate between 6:00 am and midnight, and spend the night in either Macon or Charlotte. One spare trainset is assumed in all cases.

For the basic frequency assumption of six trains per day each way, six trainsets (plus one spare) would be required for the 90 mph and 110 mph cases. However, six trains per day each way can be operated with four trainsets (plus one spare) for the 125 mph, 150 mph and 200 mph cases. There was no variation in trainset requirements between station cases within a given technology.

For the frequency assumption of four trains per day each way, four trainsets (plus one spare) would be required for the 90 mph and 110 mph cases. However, four trains per day each way can be operated with three trainsets (plus one spare) for the 125 mph, 150 mph and almost all of the 200 mph cases. In the 200 mph case the minimum run time case (case 6) can be served by two trainsets (plus one spare).

For the frequency assumption of eight trains per day each way, eight trainsets (plus one spare) would be required for the 90 mph and 110 mph cases. However, eight trains per day each way can be operated with six trainsets (plus one spare) for the 125 mph, 150 mph and almost all of the 200 mph cases. In the 200 mph case the minimum run time case (case 6) can be served by four trainsets (plus one spare). This is the same number of trainsets as required to provide six trains per day each way.

3.10 Sample Train Schedules

Sample Schedules were developed for two sample cases. The first presents a schedule for case 1, the case with the maximum number of stations, using 90 mph trains. The second presents a schedule for case 6, the minimum number of stations, using 200 mph technology. Both schedules assume six trains per day each way. All times are based on the TPC runs.

Table 3-7 Sample Schedule - 90 mph technology - Case 1

Southbound						
Departure Station	**Train #1**	**Train #2**	**Train #3**	**Train #4**	**Train #5**	**Train #6**
Charlotte, NC	6:00 AM	8:00 AM	10:00 AM	1:29 PM	3:29 PM	5:29 PM
Charlotte Airpt., NC	6:06 AM	8:06 AM	10:06 AM	1:35 PM	3:35 PM	5:35 PM
Gastonia, NC	6:18 AM	8:18 AM	10:18 AM	1:47 PM	3:47 PM	5:47 PM
Spartanburg, SC	7:02 AM	9:02 AM	11:02 AM	2:31 PM	4:31 PM	6:31 PM
Spart/Green Airpt., SC	7:22 AM	9:22 AM	11:22 AM	2:51 PM	4:51 PM	6:51 PM
Greenville, SC	7:34 AM	9:34 AM	11:34 AM	3:03 PM	5:03 PM	7:03 PM
Clemson, SC	8:01 AM	10:01 AM	12:01 PM	3:30 PM	5:30 PM	7:30 PM
Toccoa, GA	8:30 AM	10:30 AM	12:30 PM	3:59 PM	5:59 PM	7:59 PM
Gainesville, GA	9:02 AM	11:02 AM	1:02 PM	4:31 PM	6:31 PM	8:31 PM
Atlanta North, GA	9:34 AM	11:34 AM	1:34 PM	5:03 PM	7:03 PM	9:03 PM
Atlanta, GA	9:51 AM	11:51 AM	1:51 PM	5:20 PM	7:20 PM	9:20 PM
Atlanta Airpt., GA	10:05 AM	12:05 PM	2:05 PM	5:34 PM	7:34 PM	9:34 PM
Griffin, GA	10:34 AM	12:34 PM	2:34 PM	6:03 PM	8:03 PM	10:03 PM
Macon, GA	11:29 AM	1:29 PM	3:29 PM	6:58 PM	8:58 PM	10:58 PM
Northbound						
Departure Station	**Train #1**	**Train #2**	**Train #3**	**Train #4**	**Train #5**	**Train #6**
Macon, GA	6:00 AM	8:00 AM	10:00 AM	1:29 PM	3:29 PM	5:29 PM
Griffin, GA	6:55 AM	8:55 AM	10:55 AM	2:24 PM	4:24 PM	6:24 PM
Atlanta Airpt., GA	7:24 AM	9:24 AM	11:24 AM	2:53 PM	4:53 PM	6:53 PM
Atlanta, GA	7:38 AM	9:38 AM	11:38 AM	3:07 PM	5:07 PM	7:07 PM
Atlanta North, GA	7:55 AM	9:55 AM	11:55 AM	3:24 PM	5:24 PM	7:24 PM
Gainesville, GA	8:27 AM	10:27 AM	12:27 PM	3:56 PM	5:56 PM	7:56 PM
Toccoa, GA	8:59 AM	10:59 AM	12:59 PM	4:28 PM	6:28 PM	8:28 PM
Clemson, SC	9:28 AM	11:28 AM	1:28 PM	4:57 PM	6:57 PM	8:57 PM
Greenville, SC	9:55 AM	11:55 AM	1:55 PM	5:24 PM	7:24 PM	9:24 PM
Spart/Green Airpt., SC	10:07 AM	12:07 PM	2:07 PM	5:36 PM	7:36 PM	9:36 PM
Spartanburg, SC	10:26 AM	12:26 PM	2:26 PM	5:55 PM	7:55 PM	9:55 PM
Gastonia, NC	11:11 AM	1:11 PM	3:11 PM	6:40 PM	8:40 PM	10:40 PM
Charlotte Airpt., NC	11:23 AM	1:23 PM	3:23 PM	6:52 PM	8:52 PM	10:52 PM
Charlotte, NC	11:29 AM	1:29 PM	3:29 PM	6:58 PM	8:58 PM	10:58 PM

Table 3-8 Sample Schedule - 200 mph technology - Case 6

Southbound						
Departure Station	**Train #1**	**Train #2**	**Train #3**	**Train #4**	**Train #5**	**Train #6**
Charlotte, NC	6:00 AM	8:00 AM	10:35 AM	12:35 PM	3:10 PM	5:10 PM
Charlotte Airpt., NC	6:05 AM	8:05 AM	10:40 AM	12:40 PM	3:15 PM	5:15 PM
Gastonia, NC	-	-	-	-	-	-
Spartanburg, SC	-	-	-	-	-	-
Spart/Green Airpt, SC	6:37 AM	8:37 AM	11:12 AM	1:12 PM	3:47 PM	5:47 PM
Greenville, SC	-	-	-	-	-	-
Clemson, SC	-	-	-	-	-	-
Toccoa, GA	-	-	-	-	-	-
Gainesville, GA	7:20 AM	9:20 AM	11:55 AM	1:55 PM	4:30 PM	6:30 PM
Atlanta North, GA	-	-	-	-	-	-
Atlanta, GA	7:46 AM	9:46 AM	12:21 PM	2:21 PM	4:56 PM	6:56 PM
Atlanta Airpt., GA	7:59 AM	9:59 AM	12:34 PM	2:34 PM	5:09 PM	7:09 PM
Griffin, GA	-	-	-	-	-	-
Macon, GA	8:35 AM	10:35 AM	1:10 PM	3:10 PM	5:45 PM	7:45 PM
Northbound						
Departure Station	**Train #1**	**Train #2**	**Train #3**	**Train #4**	**Train #5**	**Train #6**
Macon, GA	6:00 AM	8:00 AM	10:35 AM	12:35 PM	3:10 PM	5:10 PM
Griffin, GA	-	-	-	-	-	-
Atlanta Airpt., GA	6:36 AM	8:36 AM	11:11 AM	1:11 PM	3:46 PM	5:46 PM
Atlanta, GA	6:48 AM	8:48 AM	11:23 AM	1:23 PM	3:58 PM	5:58 PM
Atlanta North, GA	-	-	-	-	-	-
Gainesville, GA	7:15 AM	9:15 AM	11:50 AM	1:50 PM	4:25 PM	6:25 PM
Toccoa, GA	-	-	-	-	-	-
Clemson, SC	-	-	-	-	-	-
Greenville, SC	-	-	-	-	-	-
Spart/Green Airpt., SC	7:58 AM	9:58 AM	12:33 PM	2:33 PM	5:08 PM	7:08 PM
Spartanburg, SC	-	-	-	-	-	-
Gastonia, NC	-	-	-	-	-	-
Charlotte Airpt., NC	8:30 AM	10:30 AM	1:05 PM	3:05 PM	5:40 PM	7:40 PM
Charlotte, NC	8:35 AM	10:35 AM	1:10 PM	3:10 PM	5:45 PM	7:45 PM

3.11 Conclusions

Ridership estimates were prepared for five speed/technology assumptions, seven station/alignment configurations, and for the situations where the proposed HSR service north of Charlotte is running and where the proposed HSR service north of Charlotte is not running and existing Amtrak services must be used. Summary results are available for 2015, 2020, 2025, 2030, 2035 and 2040. Results are available for 420 individual "cases".

The analysis period covered the years 2015 to 2040. **Ridership increases with the passage of time due to growth in population, income and travel in the corridor.** As an example ridership for the 200 mph technology applied to the case with all fourteen stations with existing Amtrak service north of Charlotte is estimated to grow from 825,000 in 2015 to 1,731,000 in 2040, an average annual rate of growth of 3%.

The following conclusions are based on the results for 2025 but are representative of results for any given forecast year.

Ridership increases with increasing speed within any given station/alignment configuration. For the specific case indicated above ridership was estimated at 822,000 using the 90 mph technology and at 1,090,000 when the 200 mph trains were utilized.

Ridership decreases as stations are eliminated within any given technology assumption. For the specific case indicated above annual ridership was estimated at 1,090,000 with the station/alignment configuration including all 14 stations and at 860,000 with the station/alignment configuration including 7 stations when the 200 mph trains were utilized.

The existence of an attractive HSR service north of Charlotte attracts considerable additional ridership within the Macon-Charlotte study corridor, on the order of 100,000 trips per year. Ridership for the 200 mph technology applied to the case with all fourteen stations with existing Amtrak service north of Charlotte is estimated at 1,090,000 while ridership for the same case with service coordinated with the proposed HSR service north of Charlotte is estimated at 1,190,000.

4. ROUTE AND CAPITAL COST ESTIMATION

4.1 Introduction

The railed vehicle technology selected for study on the Macon-Atlanta-Greenville-Charlotte rail corridor encompasses operations with operating speeds of 90, 110, 125, 150, and 200 mph. There are currently several passenger services operating to 125 mph around the US. Amtrak operates on the Northeast Corridor in sections up to 150 mph, and other countries have been routinely operating trains in revenue service with speeds of 200 mph and beyond. This feasibility study proposes alignment options for different station selection and vehicle speed regimes.

To approximate the capability of high-speed passenger rail in the Macon-Atlanta-Greenville-Charlotte rail corridor, this study uses similar, but updated, technologies from the Federal Railroad Administration's 1997 Commercial Feasibility Study (CFS): *High Speed Ground Transportation for America*. The trainset configurations are defined to evaluate different technology options with maximum operating speeds ranging from 90-200 mph. The existing track configuration is derived from freight railroad track charts, and modified routes are developed for each case studied. With this input, the TPC derives the general motion of a passenger consist from a simplified yet verifiable calculation using Newtonian laws of motion, train resistance, and motive propulsion power. Volpe is using a TPC originally developed by the University of Illinois in the mid-1970's, and more recently extensively modified by Volpe to specifically evaluate passenger rail service. The program has been validated, calibrated, and utilized in research by the Federal Railroad Administration Office of Research and Development.

The technology considered includes:

> 90 and 110 mph diesel - roughly follows existing freight railroad alignment with new single or double concrete tie track. Single track shares cross-overs with and trackage with railroad, some high speed sidings, close most grade crossings
>
> 125 mph diesel – minimizes track sharing with freight railroad, very few grade crossings allowed, significant new ROW required
>
> 150 mph diesel - no track sharing with freight except where speeds drop below 125 mph near stations, no grade crossings, mostly new ROW. All new double concrete tie tracks.
>
> 150 mph electric - same as 150 mph diesel above except additional ROW required for electrification (poles to hang catenaries, substations and fencing). All new double concrete tie tracks.

200 mph electric - route as close to straight line between stations as possible, extra ROW for electrification necessary, no track sharing except where speeds drop below 125 mph entering and departing stations.

A more thorough explanation and description of the technology appears in Appendix G.

4.2 Construction Requirements

It is recommended that, for speeds of 90 mph and above, the high-speed service have its own dedicated track. For 90 and 110 mph this could be a single track with long passing sidings. For higher speeds, double track is recommended with cross-overs every 25 to 30 miles. There are areas where the passenger line could share right-of-way with the freight lines especially near stations where the passenger vehicle speed is reduced because the train is either decelerating or accelerating.

A dedicated line for passenger traffic offers many advantages over shared track:

1. Safety – Above 125 mph, mixed freight and passenger service is not allowed by regulation. At slower speeds (90 – 110), the possibility of collisions is reduced. Dedicated track can be grade separated eliminating crossings.
2. Maintainability - Track maintenance requirements for passenger-only track are significantly reduced. Initially, 132 RE rail could be used rather than 136 or 141 lb. per yard rail. Mixed freight and passenger service would demand the heavier rail sections to extend rail life.
3. Feasibility – As speeds increase, the high-speed alignment will deviate from the existing freight line more to straighten or eliminate speed-reducing curves. In addition, delays, waiting in sidings while freight traffic clears, will not be a problem. Freight railroad dispatchers, even where required to not interfere with passenger trains, will allow tardy freight to move while the passenger train waits.

The economies of sharing track with freight railroads are usually over estimated. First, the tracks need to be completely reconstructed in order to take the additional superelevation and provide a stable track bed to hold surface and line for the higher speeds. At least three, and in cases of poorer soils encountered in many places along the line, six to eight feet of subgrade need be replaced with compact select material to minimize track geometry changes. Stabilizing the rail running surface also requires extensive improvement to drainage systems and structures. All of these factors tend to increase the cost of rehabilitation where new construction becomes an attractive option. In addition, the railroad, the owner of the shared track facilities usually demands a premium from the passenger system for maintenance and repair of the track.

4.3 Alignment

The alignment options selected for each speed scenario are approximate, made to assess feasibility and estimate costs. Nearly exact alignments will be determined during the preliminary engineering stage. Many of the segment alignments are identical for different speed and station scenarios. Costs for each segment are estimated and then summed for each scenario.

Further engineering studies might uncover development plans, zoning laws or *in situ* conditions that prohibit that exact alignment from being implemented.

For the lower speed categories (90, 110 and, to some extent, 125 mph) as a general rule, the proposed alignment follows the existing freight alignment. The base case was to assume that the existing alignment would be rebuilt with no curve realignment. Maximum superelevation was applied and the maximum permissible vehicle speeds along this route calculated. For the 90, 110 and 125 mph speeds, curves were realigned, with some right-of-way (ROW) taking required to allow the maximum speeds throughout. All single track portions of the railroad were replaced with double track, one track dedicated to passenger service.

For the 150, 200 mph cases, the alignment differs widely from the existing track ROW, principally to avoid small town centers *e.g.* Easley, SC or Mt. Airy, GA. No grade crossings are allowed. The higher speed routes are straighter and therefore shorter than the slower speed routes. Specific corridor segments are discussed below.

4.3.1 Charlotte, North Carolina to Greenville, South Carolina

Exiting Charlotte Station, the alignment follows the existing trackage with multiple grade crossings as well as grade separations. The only major deviation before the airport is at Golf Drive where either the track is elevated or major Right-of-Way (ROW) taking, including buildings will be required. Although elevating the track will nominally preserve the neighborhood and not disrupt local traffic, there is a stigma attached to elevated rail structures and some action by neighborhood groups can be anticipated.

It is suggested that the higher speed alignment abandon the freight corridor after the airport and follow Routes 485 and 85 to Gastonia. Figure 4-2 below demonstrates the major ROW taking, including homes and businesses if the corridor followed the existing rail line and speeds were increased to 125 or 200 mph. Sharing alignment with the highway will minimize land taking and home and business disruption. Access is controlled everywhere except at interchanges. The interchanges will require major reconstruction to provide access and some of the service roads may need to be relocated.

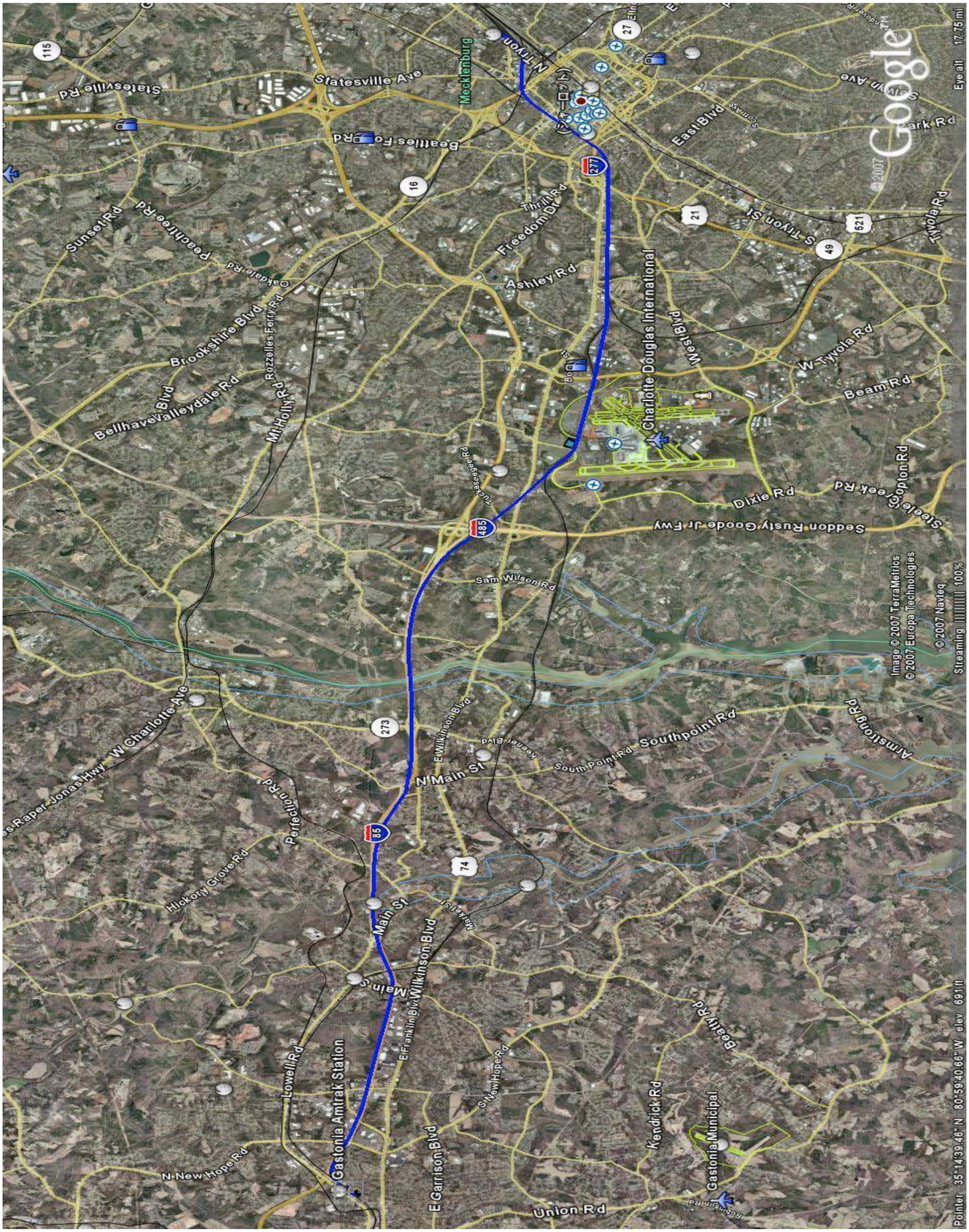
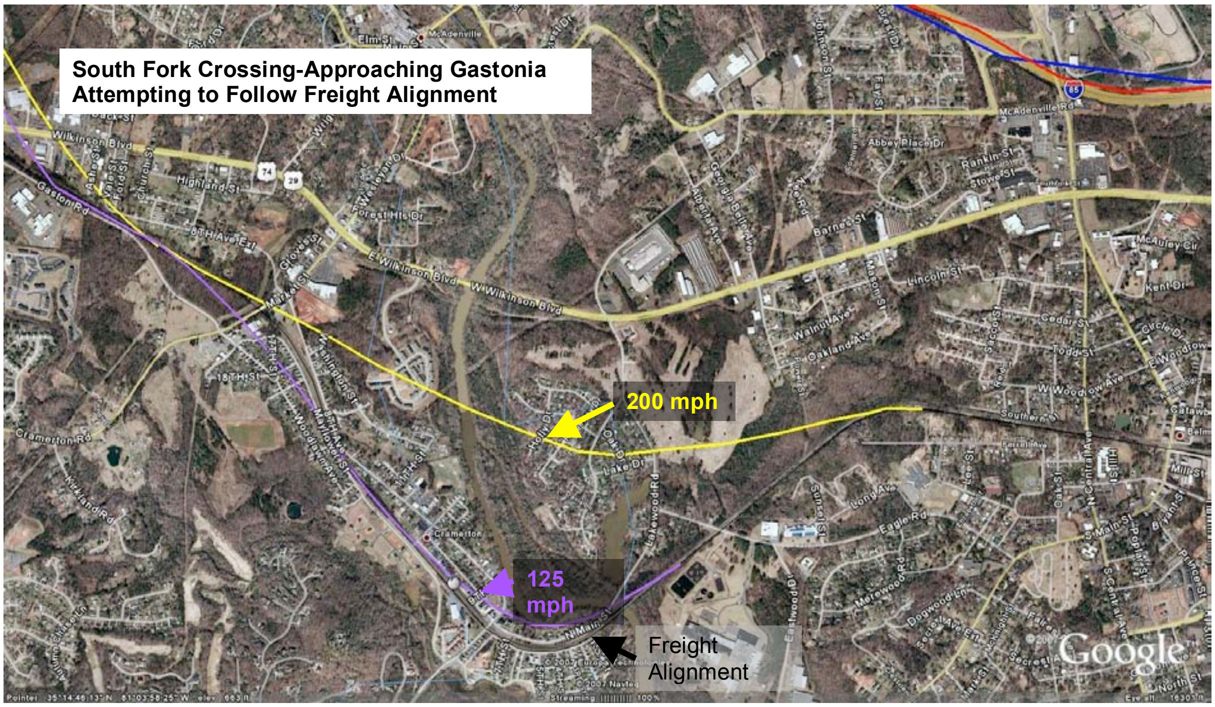


Figure 4-1 Approximate Charlotte, North Carolina, to Gastonia

Figure 4-2 Demonstrating Alignment Options for 125 and 200 mph Alignments



4.3.2 Gastonia, North Carolina to Greenville, South Carolina

From Gastonia, the proposed alignment follows I-85 and then veers off to follow, in general the existing freight ROW. The freight alignment is relatively straight and eventually parallels route 29. There are several deviations to avoid cities and villages.

ROW becomes tighter in Spartanburg and consideration must be given to improvements to Spartanburg station. Continuing southwest, the corridor passes north of the Greenville Spartanburg International Airport (GSP), a station stop in cases 1 and 6. As in the rest of the corridor, there are major deviations from the railroad alignment to remove excessive curvature. There are no significant problems arriving at Greenville station from the north. There are some industrial areas where ROW will be tight and considerable construction which may complicate ROW acquisition in the near future.

Greenville station is close to downtown; but in a rundown area in need of urban renewal. The station itself is open limited hours and offers minimal amenities to potential travelers. {Figure 4-3 and 4-4 below)

Figure 4-3 Greenville Station on Norfolk Southern Property

Figure 4-4 Limited Hours and Amenities at Greenville Station

4.3.3 Greenville, South Carolina to Gainesville, Georgia

Several alignments were postulated in this area depending on the station alternatives. The existing freight alignment is not straight enough to tolerate even 90 mph service. There are many stream crossings and several major structures across the Tugalu River will be costly. An alternative corridor from Spartanburg to Greenville was considered along I-85. This alignment would be very convenient for Spartanburg, but would require building a new station at Greenville, well south of the city. It would not be convenient to downtown and, depending on the next station, Clemson, Gainesville or Atlanta, would require extensive land taking. Some opposition from Greenville citizens to moving the station has already surfaced.

South of the existing Greenville station, there appears to be sufficient corridor width to insert double, high-speed track (see Figure 4-5), although structures are very old and many may need to be completely replaced due to potential vibration damage from high-speed service.

Figure 4-5 South of Greenville Station

Further south, the existing railroad traverses several small towns on its way to Clemson. Typically, the tracks bisect the town (see Figure 4-6) and present a safety and an access problem.

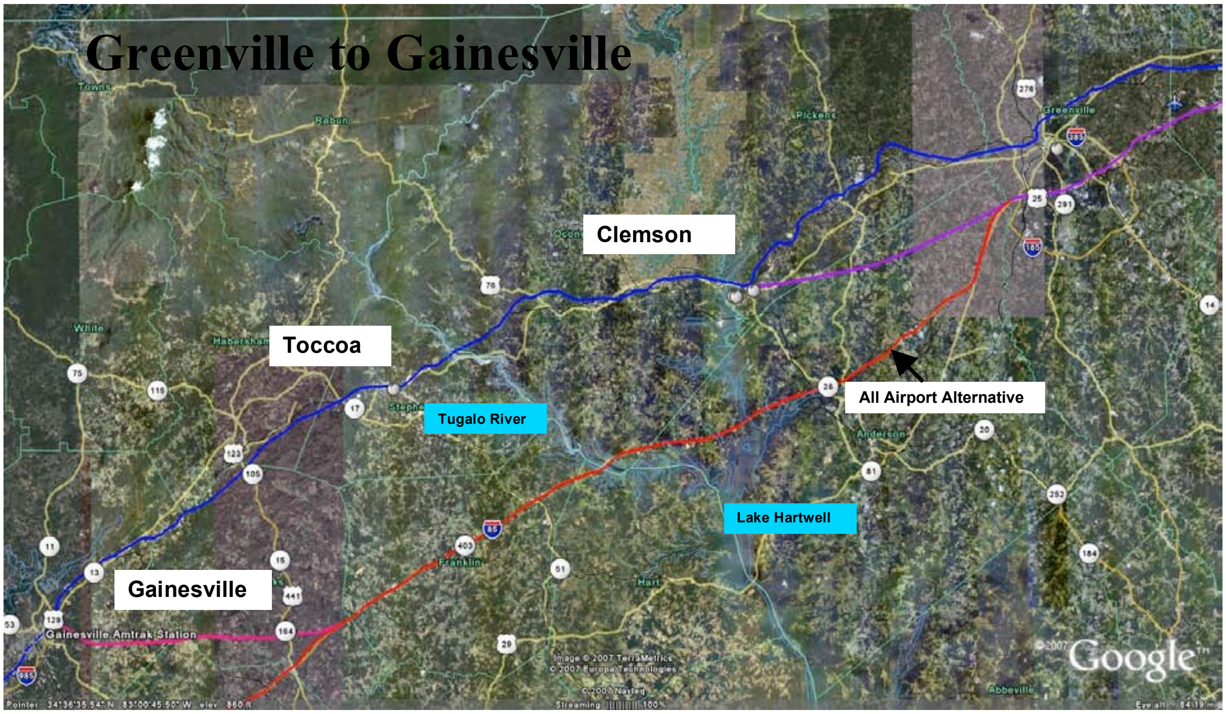
Figure 4-6 Double Track and Siding on Route 135 in South Carolina

Approaching Clemson, the alignment needs severe straightening; but, except as it nears Clemson, there is sufficient space with relatively inexpensive acquisition costs. South of Clemson, major structures will be required to traverse the Tugalu River. Along the I-85 corridor, see Figure 4-7 below, the structure costs could well increase[1].

There is sufficient room at the existing Amtrak station to put in a larger, customer-friendly building and a parking structure. Moving on further south, the alignment will require several major deviations from the railroad route. Toccoa is another city bisected by the tracks. Some grade crossings can be allowed because of the station stop so disruption of local traffic can be minimized. If, express trains run through Toccoa at speed without stopping, grade separations will be unsightly, disruptive – but necessary. Southwest of Toccoa, ROW can generally be shared with the railroad with little exception. Approaching Gainesville, there should be no major obstacles to sharing ROW or acquiring ROW for double track. The station area in Gainesville, Figure 4-8, needs to be upgraded but appears to have sufficient space to allow significant modification.

[1] The length and number of the structures will increase along I-85; but foundations could well be more expensive near Clemson. The preliminary design will take this all into account, sample the underlying soils and produce a more accurate cost assessment.

Figure 4-7 Corridor Alternatives in Greenville, South Carolina to Gainesville, Georgia Segment



The station is near the central business district and could become a focal point for rehabilitation for the area which is slightly degraded.

An alignment that by-passes both Clemson, South Carolina and Toccoa, Georgia by following I-85 would require that the passenger line split off and head due west from I-85. A great deal of this land is free of structures or homes and ROW may be relatively inexpensive to secure. There is a significant raise in elevation between Toccoa and Gainesville, which may result in additional construction costs.

Figure 4-8 Amtrak Station at Gainesville

4.3.4 Gainesville to North Atlanta (Doraville)

The corridor between Gainesville and Doraville is straight; but of increasing density as it approaches Atlanta. Figure 4-9 shows the corridor.

Figure 4-9 High-Speed Alignment between Gainesville, Georgia and Doraville, Georgia

4.3.5 Atlanta Alternatives

There are two alternatives for approaching the major Atlanta high-speed station, *i.e.* the multi-modal passenger terminal (MMPT). One employs existing NS ROW, the "Decatur Belt", approaching the MMPT from the east. The alternative uses CSX track through the very busy wye between Simpson and Edgewood and enters the MMPT from the west. The two alternatives are depicted in Figures 10 and 11 below. The CSX track has heavy freight traffic and does not exit the MMPT to the east; but instead must "back" out, through the wye, before continuing south to rejoin NS ROW and continue to Macon. The preferred route is the longer eastern route along former NS ROW called the "Decatur Belt".

The Decatur Belt

The Decatur Belt Line (DBL) is the preferred alternative for several reasons. It is a continuous movement through the MMPT, without any maneuverings that could cause delays or potentially present safety problems. The corridor can be exclusively dedicated to passenger traffic (up to the merge with CSX tracks after Dekalb Avenue). Although it will require new track, the ROW will allow two tracks and the existing structures, though aged) exist to cross almost all streets. Only one potential grade crossing will be required.

The DBL separates from the existing Amtrak route around Plasters Avenue Northeast, just north of I-85 and crosses the interstate heading southeast. The ROW travels alongside the Ansley Golf Course and crosses under Piedmont Avenue (a four-lane, undivided major thoroughfare). The track disappears in some development adjoining Evelyn Street. The DBL continues as a single track under Park Drive as well as under Monroe Drive and Virginia Avenue. The track crosses over Ponce De Leon Avenue over a bridge that needs to be replaced. Another bridge needing replacement crosses over Virginia Avenue. Further along the DBL a two-track bridge crossing Ralph McGill Boulevard needs to be replaced. The route then travels under the four-lane, divided Freedom Parkway and one of its ramps before continuing under Highland Avenue. The underpass at Edgewood will need to be upgraded.

A grade crossing of Lake Avenue will either need to be eliminated or otherwise protected, just north of the Edgewood underpass. From Edgewood to Dekalb is approximately 680 feet. Adjacent to Dekalb Avenue is the elevated MARTA transit structure traveling between the King Memorial Station and Inman Park. The CSX tracks that the DBL needs to merge with to approach the MMPT are on the other side of the transit structures from Dekalb.

A grade crossing at this location is possible, although it would disrupt traffic on Dekalb and may require some alterations to the MARTA structures. The high-speed train should be traveling at less than 80 mph at this location, decelerating as it approaches the MMPT. Raising Dekalb over the tracks would cut off some access to adjacent streets but could be done without impacting the underpasses beneath the tracks at Boulevard and Krog.

Once on the CSX property an arrangement must be made with CSX to share track or fit another track into a very narrow ROW crossing I-75. Unless the freight railroad and the high-speed line share tracks, the bridges over Jesse Hill Drive and Piedmont Avenue will have to be reconstructed. Even if track is shared, these overpasses may need rehabilitation. The route goes underground at Courtland Street, passes under a parking garage and Central Avenue and Pryor before arriving at the MMPT. Leaving the MMPT will not present as many interesting engineering concerns as approaching it.

Turning the dilapidated brick building shown in Figure 12 into the multimodal hub envisioned will be a major cost. For the Decatur Belt Alternative, additional cost will be required to expand the underground space at the left of Figure 12 to accommodate the passenger track.

Figure 4-10 Alternative Routes through Atlanta

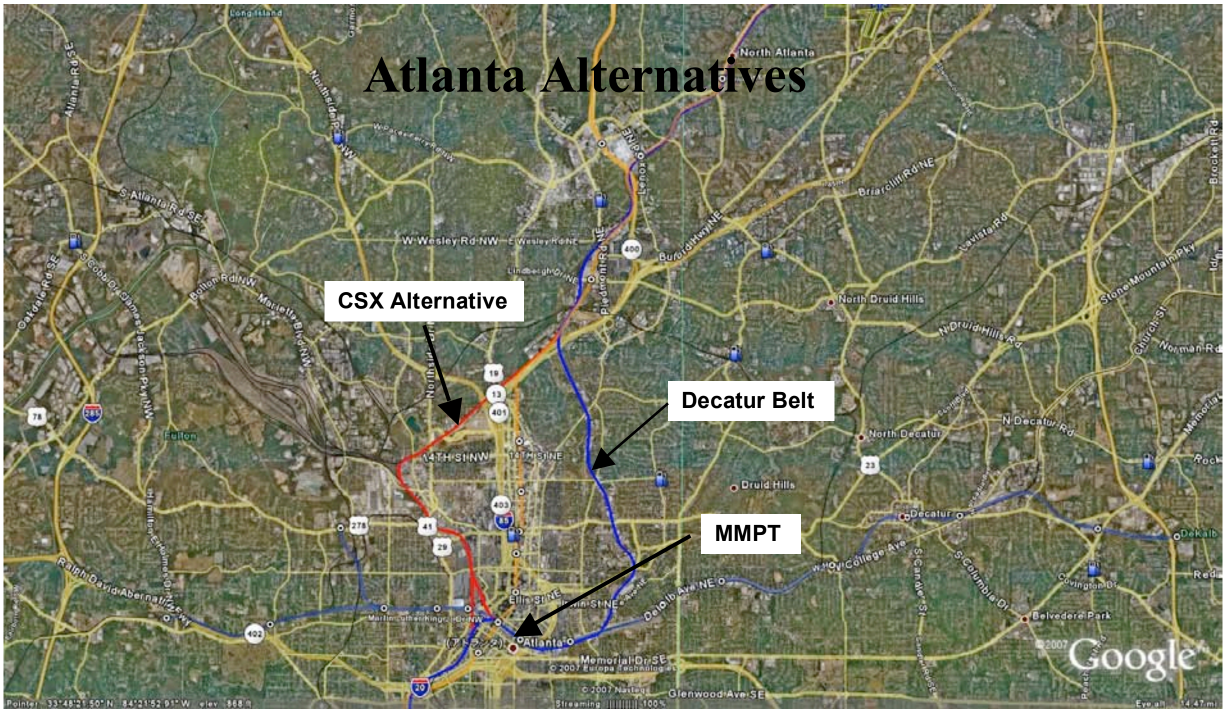


Figure 4-11 Approaching the MMPT

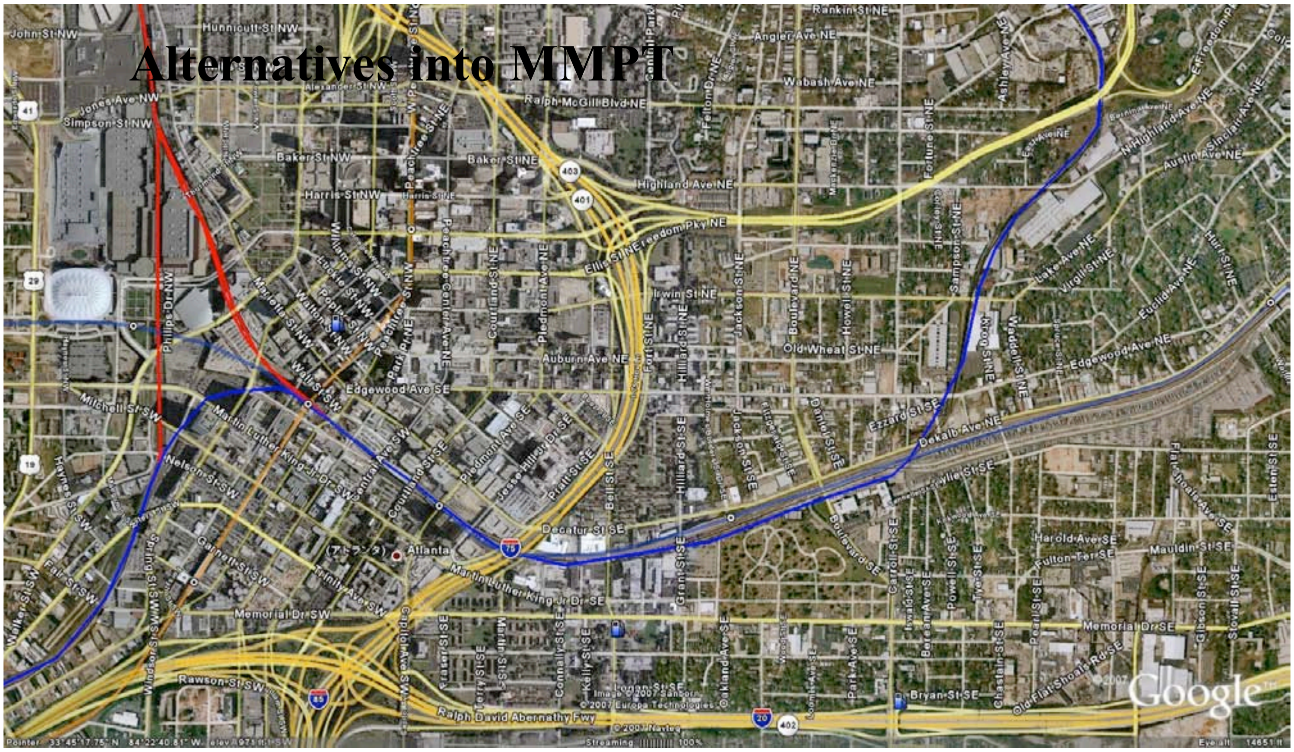


Figure 4-12 The Site of the Proposed MMPT Showing the existing NS and CSX Tracks on the Left and the MARTA Lines (in the Trenches) on the Right

The All CSX Alternative

The other potential route follows CSX active alignment to the west and, after entering “the wye”, around Simpson Street Northwest, south into the MMPT. This route has no possibility of continuing south once it has entered the MMPT. The train must backup past Simpson Street before continuing south to join the same route used by the DBL to travel to the airport station. Although the maneuver only costs this route five minutes in extra time, the complexity of maneuver adds a potential for additional delays as well as safety problems. Amtrak may not accept this route which may make it no alternative at all. The route is only approximately ½ mile shorter than the DBL which at an average of 90 miles per hour is less than one minutes traveling time difference.

The CSX Alternative begins where the DBL splits off at Plasters Avenue Northwest. It continues southwest along I-85 on existing freight ROW. It turns southeast at the Foster

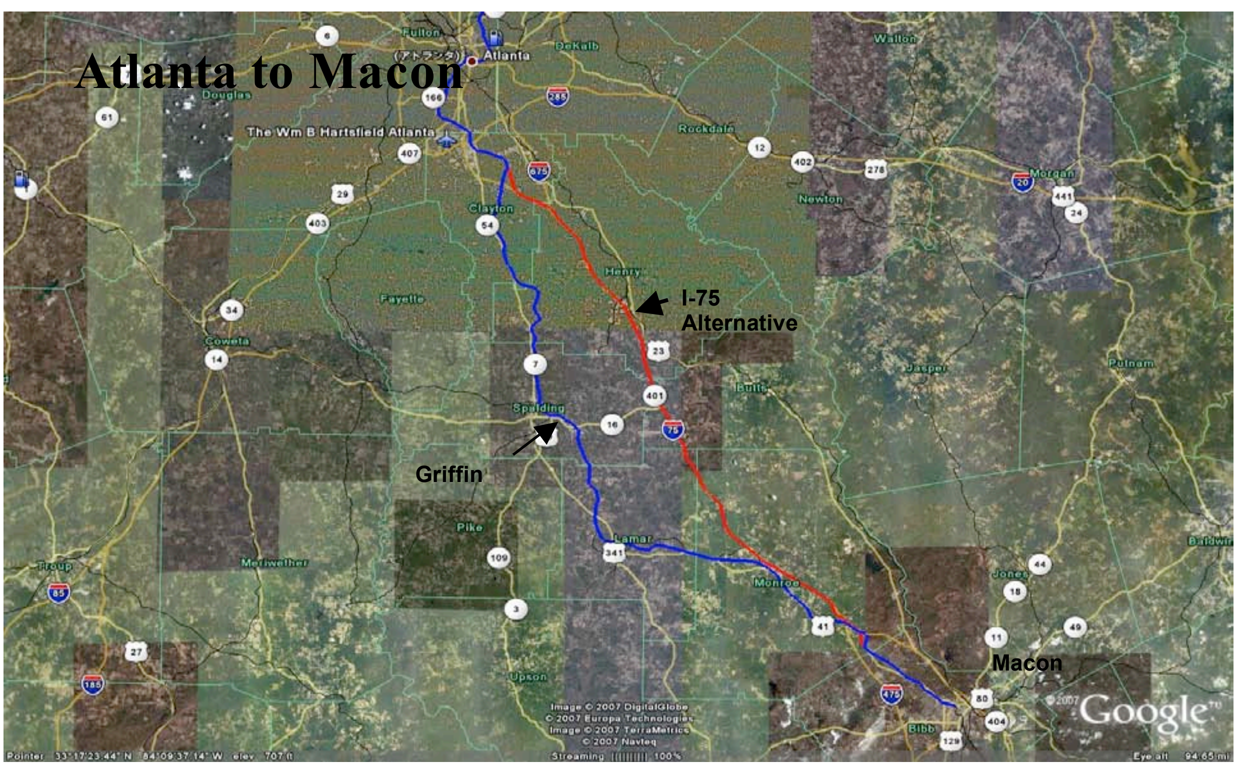
Street wye and continues on CSX ROW, turning more easterly at the Simpson Street wye. Although, generally, there appears to be sufficient space to accommodate two high-speed tracks, after Simpson Street, it may be necessary to use the freight track most of the way into the station. The foundry Street crossing probably will need to be eliminated.

4.3.6 Atlanta to Macon Georgia

There are two proposed alternatives for the route from Atlanta to Macon. One approximately uses existing NS alignment through Griffin, Georgia, while the other by-passes Griffin altogether, breaks off from the NS south of the Atlanta airport and approximately follows I-75 to Macon. The blue route through Griffin is tortuous and substantially longer than the I-75 alternative. Using the alternative represents a 10 to 20 minute difference in trip time (at 200 and 90 mph, respectively) with no stop in Griffin in either case.

For the I-75 alternative, the highway ROW can be used in most places, and the median between the north and south lanes can also be used (particularly if employing a single track).

Figure 4-13 Two Alternative Routes between Atlanta and Macon, Georgia



4.4 Capital Cost Estimates

The capital cost valuation process provides an estimate of all capital investments necessary to develop the infrastructure and operate a high-speed rail system (as defined by the scenario development process and the projected level of demand). The variables in each scenario are: 1) technology, maximum permissible speed and propulsion technology, 2) stations visited and 3) route alignment between stations. Costs will be calculated for each scenario as well as travel times based on the routes developed. Costs for operation and maintenance shall also be estimated. The major components of capital costs include:

- Track and structures (bridges, drainage, special track work, signals etc.),
- Vehicles (power and passenger cars),
- Stations and parking structures and
- Maintenance facilities.

Adjacent tracks will be a minimum 14 feet apart on centers. Double track will require an average of 40 feet of right-of-way width; single track will require a minimum 24 feet. It is recommended that the right-of-way be fenced where possible. For the 150 and 200 mph electrified case, additional right-of-way will be required for the power poles and substations.

Major components of capital cost include:

- Track and Structures
    - Rail, Ties and Fasteners
    - Substructure Construction/Rehabilitation
        - Earthwork and Drainage
        - Security Systems
    - Sidings and Special Trackwork
- Major Civil Structures
    - Bridges
    - Stations
    - Ancillary Facilities
        - Equipment Maintenance and Repair Shops
        - Vehicle Storage Yards
- Right-of-Way
    - Land
    - Buildings
- Train Control, Signaling Systems

- Grade-Crossing/Access Control
- Roadway Modifications
  - Interstate Reconstruction
  - Interchange and Ramp Modifications
- Electrification
  - Catenaries
  - Substations
  -

The unit costs used in this feasibility study include:

- Rail
  - 132RE ($70 K/mile)
  - 136RE ($72 K/mile)
- Ties and Fasteners
  - Concrete ties with elastic fasteners
  - 125 mph and less – 30 inches on center
  - 150 mph and more – 24 inches on center
- Foundation work includes utilities and drainage – $250 K/mile added where very weak foundations exist.
- Sidings – roughly every 25 miles
- High speed turnouts $150 K/each
- Sidings
  - 90 and 110 mph 2 miles long
  - 125 mph 3 miles long
  - 150 and 200 mph 5 miles long

Structures:

- Major Water Crossings estimated individually
- Overpasses (<250 feet) $16 K/foot
- Elevated track $16K/foot plus foundation costs
  $10 -25 K/mile

Electrification:

- $1.5 M/mile
- Additional ROW for substations

Interstate Modifications:

- Lane Modifications to allow track inclusion $1.5 M/mile
- Interchange structures and modifications $5-10 M/each

Signal and Control Systems:

- 125 mph speeds and below - $140 K/mile
- Speeds above 125 mph - $200 K/mile

Right-of-Way (ROW):

- Rural - $75 K/acre

- Suburban - $100 K/acre
- Urban - $125 K/acre
- Residential Property - $175 K/each
- Commercial Buildings - $300 K/each

For this feasibility study estimates were made for each technology broken down by segments from Charlotte to Atlanta and from Atlanta to Macon. The capital cost for electrifying at 150 mph and 200 mph are considered the same because the guideways are the nearly identical with the slight variations in curvature not resulting in a significant cost variation. The estimates shown below are for the "all station" case. Eliminating stations in the other cases considered would reduce costs by $5 M to $20 M depending on the number of stations eliminated.[2] These estimates reflect costs in 2006 dollars projected to 2015.

	90 – 110 MPH	125 MPH	150 MPH Diesel NS Corridor	150 MPH Diesel I-75 Corridor	150-200 MPH Electrified I-75 Corridor
Charlotte to Atlanta	$1,015M	$1,162M	$1,379M	$1,379M	$1,800M
Approximate Distance	262	262	262	262	262
Cost/mile	$3.9M	$4.4M	$5.3M	$5.3M	$6.9M
Atlanta to Macon	$325M	$426M	$544M	$430M	$690M
Approximate Distance	103	103	103	88	88
Cost/mile	$3.2M	$4.1M	$5.3M	$4.9M	$7.8M
Subtotal + 25% Contingency	$1,675M	$1,985M	$2,405M	$2,261M	$3,113M
Vehicle Cost*	$105M	$75M	$115M	$115M	$240M
Total	$1,780M	$2,060M	$2,520M	$2,376M	$3,353M

[2] Station estimates were as follow: MMPT $25 M; Charlotte and Macon were $10 M each; the airport stations $5 million each; Greenville $5 M; N. Atlanta $3 M; Clemson $3 M: and Toccoa and Griffin $1 M each. These costs could be less, or much more depending on what the community wants to spend.

There was very little difference in distances and associated costs between station alternatives. Straightening curves was off-set by additional length avoiding villages and towns.

*Vehicle costs were estimated as 7 trainsets at $15 M /set for the 90-1100mph case, 5 trainsets at $15 M/ set for the 125 mph case, 5 trainsets at $23 M/ set for the 150 mph diesel case, and 5 trainsets at $48 M/ set for the 200 mph case. The number of trainsets includes a spare trainset in all cases.

Table 4-1 Equipment and Capital Cost Summary

5. OPERATING AND MAINTENANCE COSTS

5.1 Introduction

Operating & Maintenance (O&M) costs are compared with system revenues in assessing the financial viability of various scenarios or service options. Assumptions about technologies, alignments and operations affect O&M costs both directly and through their effect on ridership levels over time, so there is no single estimate of a hypothesized system's O&M costs. Instead, a cost model is used to estimate the variations in cost corresponding to the various combinations inputs for the scenarios considered. The SEHSR O&M costs were estimated for all ridership/revenue scenarios (speeds, stations, years, etc.) and are reported in 2006 dollars.

5.2 General Methodology

Annual O&M cost estimates were calculated as the sum of the products of various cost drivers and unit costs. Cost drivers were drawn from SEHSR project analyses. The cost driver measures used are train miles, train hours, passenger boardings and route miles.

Unit costs were drawn from the results of the O&M model used for the 1997 FRA Report to Congress on HSR[1] generally referred to as the Commercial Feasibility Study, or CFS for short. Unit costs derived from the CFS were inflated to 2006 dollars. Unit costs used in this study are at the function level of the CFS model. These five functions are:

- Maintenance of way
- Maintenance of equipment
- Transportation (revenue operations)
- Passenger traffic &services
- General and administrative

Maintenance of way costs are calculated as a function of dollars per route mile, Maintenance of equipment costs are calculated as a function of dollars per train mile, Transportation operations costs are calculated as a function of dollars per train hour, and Passenger traffic & services costs are calculated as a function of dollars per passenger boarding. General and administrative are estimated as 20% of the sum of the other O&M costs functions.

The unit costs used in these calculations are representative costs based on the earlier CFS work for eight 'corridors.' Averages were calculated from the normalized CFS corridor cost data after first removing the highest and lowest values.

[1] *High-Speed ground Transportation for America,* Federal Railroad Administration, U.S. Department of Transportation, September 1997.

The CFS O&M cost estimates were built using cost relationships for all of the functions and sub-functions of costs involved in operating a passenger railroad. The estimates assumed the continuation of existing rail passenger industry wage rates, ratios of supervisory and support personnel to on-site primary workers, and spans of control. The estimates do, however, reflect the efficiencies inherent in a new, independent organization formed to operate high-volume, high frequency, high-speed operations with new equipment, new or refurbished infrastructure, and enhanced customer service levels, e.g., with lower train staffing levels and streamlined ticketing procedures.

More details on the assumptions underlying the CFS O&M cost model are presented in Appendix F.

5.3 Summary Base Case Results

The tables below indicate the estimated annual O&M costs for the seven cases considered for the Georgia HSR Study. These cases were described previously but can be summarized as follows:

> Case 1 includes all fourteen stations.
>
> Case 2 includes thirteen stations.
>
> Case 3a includes eleven stations.
>
> Case 3b is identical to Case 3a except for a reduced line haul time from Macon to the Atlanta airport because of a different alignment.
>
> Case 4 includes ten stations.
>
> Case 5 includes nine stations.
>
> Case 6 includes the minimum number of stations (seven).

Estimates are presented for six speed/technology assumptions (90 mph, 110 mph, 125 mph and 150 mph diesel locomotives, 150 mph and 200 mph electric locomotives) and for the assumed situations where the proposed HSR service north of Charlotte is running and where the proposed HSR service north of Charlotte is not running and, instead, existing Amtrak services must be used. The results are shown for 2025 in order to allow comparison with the previous corridor study, which used 2025 as its forecast year.[2] Results for 2015, 2020, 2025, 2030, 2035 and 2040 are presented in Appendix E.

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[2] *Macon-Charlotte Southeast High Speed Rail Corridor Plan,* prepared for Georgia Department of Transportation, South Carolina Department of Transportation, North Carolina Department of Transportation, and Federal Railroad Administration, Georgia Rail Consultants, May 2004.

Table 5-1 2025 Annual O&M Costs (millions $2006) with HSR North of Charlotte

Case	HSR 90	HSR 110	HSR 125	HSR 150 D	HSR 150 E	HSR 200
1	$31.0	$32.4	$32.0	$33.1	$44.3	$60.7
2	$30.8	$32.2	$31.8	$32.8	$44.1	$60.2
3a	$30.1	$31.4	$30.5	$31.5	$44.2	$58.6
3b	$29.4	$30.5	$30.1	$30.9	$41.7	$57.0
4	$29.7	$30.9	$30.1	$30.9	$42.1	$58.0
5	$26.8	$28.3	$27.2	$28.0	$39.2	$55.1
6	$28.7	$30.1	$29.1	$29.8	$41.0	$56.5

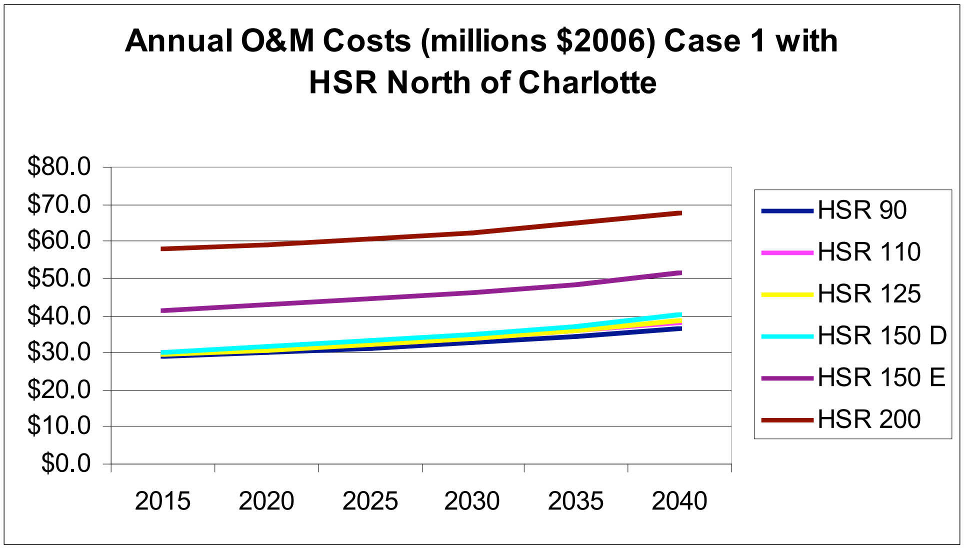
Table 5-2 2025 Annual O&M Costs (millions $2006) with Current Amtrak North of Charlotte

Case	HSR 90	HSR 110	HSR 125	HSR 150 D	HSR 150 E	HSR 200
1	$30.2	$31.6	$31.1	$32.1	$43.4	$59.7
2	$30.0	$31.4	$30.9	$31.9	$43.1	$59.2
3a	$29.3	$30.6	$29.7	$30.5	$41.7	$57.6
3b	$28.6	$29.7	$29.2	$30.0	$40.7	$56.1
4	$28.9	$30.2	$29.2	$30.0	$41.2	$57.0
5	$26.0	$27.5	$26.4	$27.1	$38.3	$54.2
6	$28.0	$29.3	$28.2	$28.9	$40.0	$55.6

The analysis period covered the years 2015 to 2040. As described in Section 3 and Appendix B, ridership increases with the passage of time due to growth in population, income and travel in the corridor and the ridership growth is the factor driving the O&M cost increase over time.

Operating costs also increase as a function of train miles, route miles, train hours and ridership, within a given technology assumption. Within a given station stop-alignment-technology-connecting service scenario, train miles, route miles, and train hours are constant and thus total operating and maintenance costs only increase as ridership increases over time. However, O&M costs also increase with increasing speed within any given station-stop case as technology increases the maximum speeds. This is illustrated in the figure below.

Figure 5-1



5.4 O&M Cost Comparisons

The O&M cost estimates shown here are comparable to those presented in the report *Macon-Charlotte Southeast High Speed Rail Corridor Plan*, but differences in cases and assumptions preclude exact comparisons. The cases/scenarios while similar are not identical.

The estimates in the previous study were for 2025 with 6 trains per day each way and assumed HSR north of Charlotte. This is consistent with the assumptions used in this study's base case. The station stops are different in that this study includes stops at the Charlotte and Greenville/Spartanburg airports and a north suburban Atlanta station. However line haul times are identical in the 90 mph case (5 hr 29 min Macon to Charlotte) and only 4 minutes different in the 110 mph case (our 5 hr 21 min vs. their 5 hr 25 min).

The previous study estimated O&M costs of $58 million ($2003 dollars) for the case using 110 mph technology. However this figure included a payment of $19.2 million to the "host" railroad and $2.8 million in costs for services north of Charlotte. This is in comparison to an estimate of O&M costs of $32.4 million presented here in which the "host" railroad costs are omitted and replaced by direct maintenance costs for the assumed separate trackage.

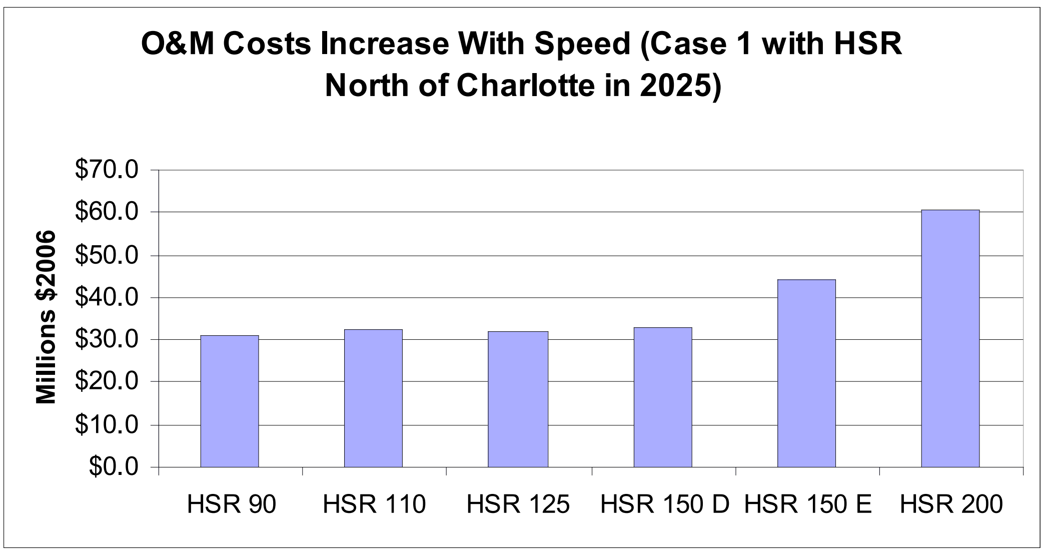
5.5 Conclusions

O&M cost estimates were prepared for six speed/technology assumptions, seven station/alignment configurations, and for the situations where the proposed HSR service north of Charlotte is running and where the proposed HSR service north of Charlotte is not running and, instead, connections to the existing Amtrak services must be used. Summary results are available for 2015, 2020, 2025, 2030, 2035 and 2040.

The following conclusions are based on the results for 2025 but are representative of results for any given forecast year.

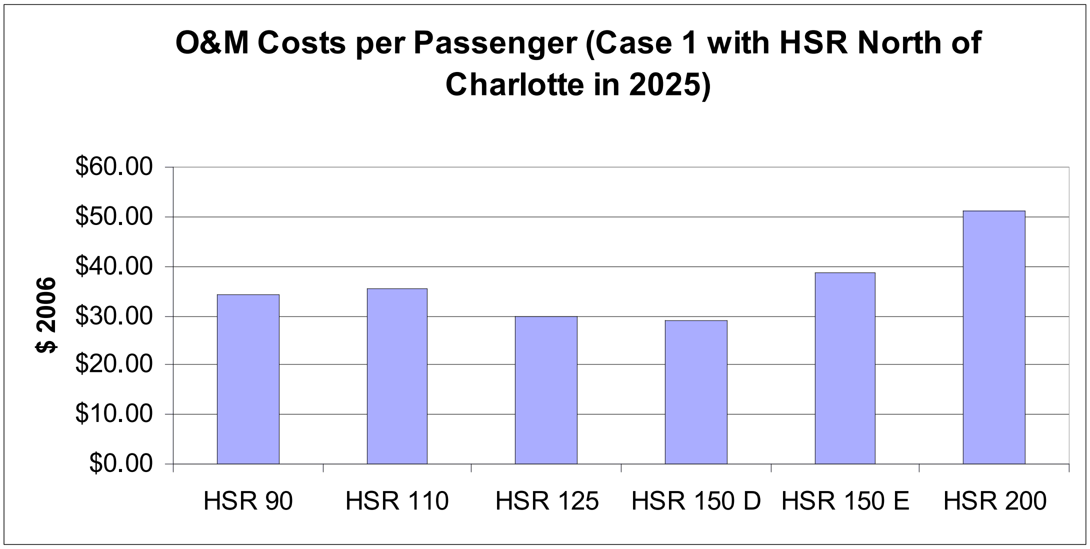
O&M costs increase with speed within any given case. The cost variation with speed is primarily due to the variation in maintenance of way costs with increasing speed and electrification. The increased ridership resulting from the higher speeds is a secondary factor in the rising O&M costs and there is a small offset due to the reduced train hours.

Figure 5-2



Average cost per passenger varies by technology with the lowest levels occurring for HSR 125 and HSR 150D.

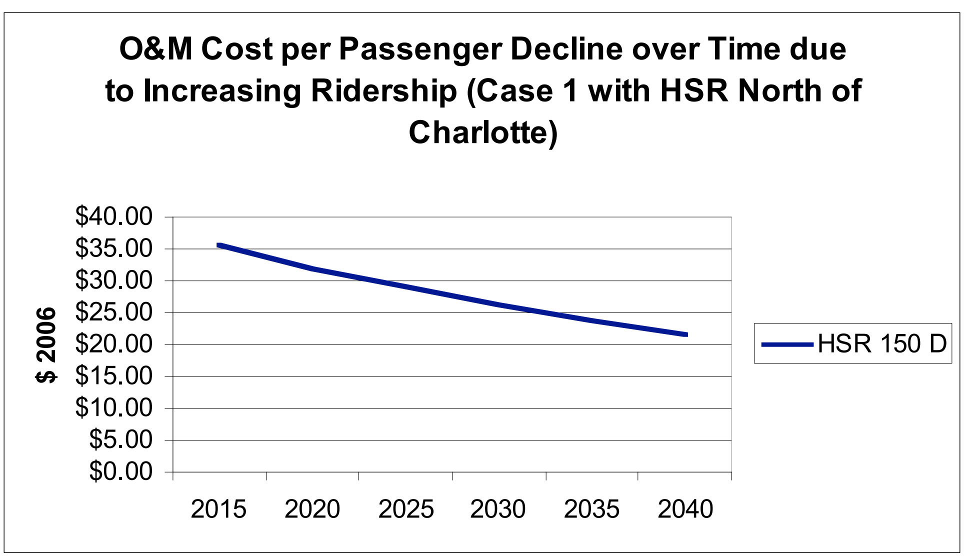
Figure 5-3



The analysis period covered the years 2015 to 2040. Ridership increases with the passage of time due to growth in population, income and travel in the corridor. Increased ridership results in increased operating costs as shown in the figure of the previous section.

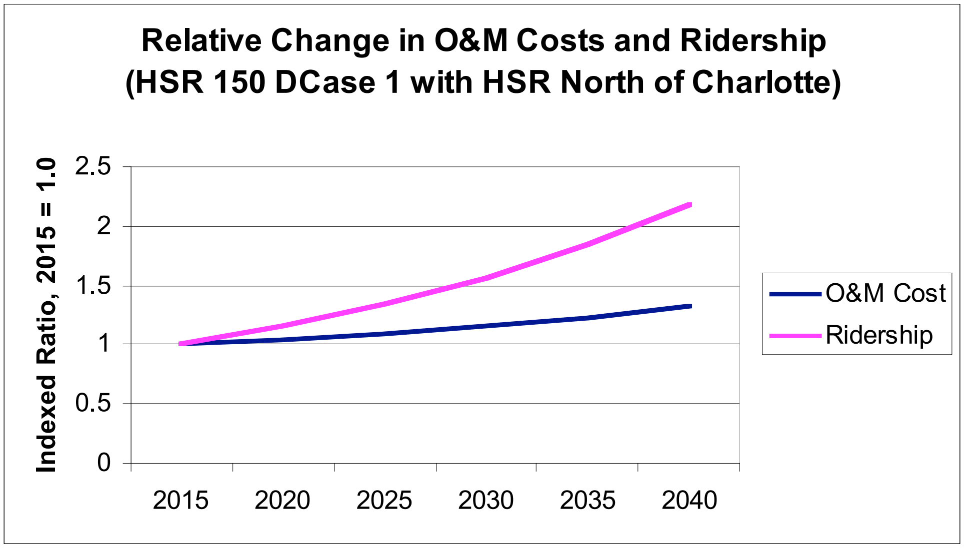
However, for any given technology average cost per passenger declines as ridership grows over time.

Figure 5-4



The decline in per passenger O&M costs occurs because total O&M costs increase at a lower rate than ridership as illustrated in the following chart.

Figure 5-5



6. FINANCIAL ANALYSIS

6.1 Introduction

A financial analysis was developed for each scenario in a process that uses outputs from the demand and cost estimating tasks. Revenue and operating cost estimates were combined to provide information on the expected profit/loss from operations in five year increments. In addition, the operating ratios were computed.

Estimates were prepared for selected years from 2015 to 2040 for all cases. These estimates were used as part of more general assessments of the financial viability of each of the rail improvement options.

Capital costs were not included in this portion of the analysis.

6.2 Summary Base Case Results

The tables below indicate the estimated profitability for the seven cases considered for the Georgia HSR Study. These cases were described previously but can be summarized as follows:

Case 1 includes all fourteen stations.

Case 2 includes thirteen stations.

Case 3a includes eleven stations.

Case 3b is identical to Case 3a except for a reduced line haul time from Macon to the Atlanta airport because of a different alignment.

Case 4 includes ten stations.

Case 5 includes nine stations.

Case 6 includes the minimum number of stations (seven).

Estimates are presented for six speed/technology assumptions (90 mph, 110 mph, 125 mph and 150 mph diesel locomotives, 150 mph and 200 mph electric locomotives) and for the situations where the proposed HSR service north of Charlotte is running and where the proposed HSR service north of Charlotte is not running and existing Amtrak services must be used. The results are shown for 2025 in order to allow comparison with the previous corridor study, which used 2025 as its forecast year[1]. Results are also shown

[1] *Macon-Charlotte Southeast High Speed Rail Corridor Plan,* prepared for Georgia Department of Transportation, South Carolina Department of Transportation, North Carolina Department of Transportation, and Federal Railroad Administration, Georgia Rail Consultants, May 2004.

for the years 2035 and 2040. Detailed results for 2015, 2020, 2025, 2030, 2035 and 2040 are presented in Appendix E. These results include annual operating and maintenance costs, fare box revenue, ancillary revenues, total revenue (the sum of ancillary and farebox revenue), profit/loss (the difference between total revenue and operating and maintenance costs) and operating ratio (total revenue divided by operating and maintenance costs). Results are available for 504 individual “cases”.

The cases where the system makes a profit are indicted by shading. In 2025, and for all prior years, the system would not be profitable for any of the station/alignment/technology combinations considered.

By 2035 in the situation where complementary HSR would be available north of Charlotte, the system would be profitable for all cases utilizing the 150 mph diesel technology and all but one of the cases utilizing the 125 mph diesel technology. In the situation where existing Amtrak services would be used north of Charlotte, the system would not be profitable for any of the station/alignment/technology combinations considered.

By 2040 in the situation where complementary HSR would be available north of Charlotte, the system would be profitable for all cases utilizing the 125 mph and 150 mph diesel technology, while one of the cases using the 90 mph breaks even. In the situation where existing Amtrak services would be used north of Charlotte, the system would be profitable for 5 of the 7 cases utilizing the 150 mph diesel technology, and one of the cases using the 125 mph technology.

Table 6-1 2025 Annual Profit/Loss (millions $2006) with HSR North of Charlotte

Case	HSR 90	HSR 110	HSR 125	HSR 150 Diesel	HSR 150 Electric	HSR 200
1	-$9.8	-$10.6	-$5.0	-$4.0	-$15.2	-$30.0
2	-$9.6	-$10.3	-$4.6	-$3.4	-$14.7	-$29.0
3a	-$11.4	-$12.1	-$6.3	-$5.2	-$16.4	-$30.5
3b	-$10.2	-$10.3	-$5.6	-$4.4	-$15.2	-$28.6
4	-$11.9	-$12.5	-$6.8	-$5.6	-$16.8	-$30.7
5	-$10.4	-$11.3	-$5.5	-$4.2	-$15.3	-$29.3
6	-$11.7	-$12.4	-$6.5	-$5.2	-$16.3	-$29.7

Table 6-2 2035 Annual Profit/Loss (millions $2006)
with HSR North of Charlotte

Case	HSR 90	HSR 110	HSR 125	HSR 150 Diesel	HSR 150 Electric	HSR 200
1	-$4.2	-$4.7	$2.5	$4.1	-$7.2	-$21.3
2	-$3.9	-$4.3	$3.1	$4.8	-$6.4	-$20.1
3a	-$6.4	-$6.8	$0.6	$2.3	-$8.9	-$22.3
3b	-$5.1	-$4.9	$1.4	$3.0	-$7.7	-$20.4
4	-$7.1	-$7.4	-$0.2	$1.6	-$9.6	-$22.8
5	-$5.2	-$5.9	$1.5	$3.4	-$7.7	-$21.0
6	-$7.0	-$7.5	$0.1	$2.1	-$9.0	-$21.7

Table 6-3 2040 Annual Profit/Loss (millions $2006)
with HSR North of Charlotte

Case	HSR 90	HSR 110	HSR 125	HSR 150 Diesel	HSR 150 Electric	HSR 200
1	-$0.3	-$0.6	$7.7	$9.6	-$1.6	-$15.4
2	$0.0	-$0.1	$8.3	$10.4	-$0.8	-$14.1
3a	-$3.0	-$3.2	$5.3	$7.3	-$3.9	-$16.8
3b	-$1.7	-$1.2	$6.1	$8.1	-$2.6	-$14.9
4	-$3.9	-$3.9	$4.3	$6.5	-$4.7	-$17.5
5	-$1.7	-$2.2	$6.3	$8.6	-$2.6	-$15.4
6	-$3.8	-$4.1	$4.6	$7.0	-$4.1	-$16.2

Table 6-4 2025 Annual Profit/Loss (millions $2006)
with Current Amtrak North of Charlotte

Case	HSR 90	HSR 110	HSR 125	HSR 150 Diesel	HSR 150 Electric	HSR 200
1	-$12.9	-$13.8	-$8.5	-$7.6	-$18.9	-$33.8
2	-$12.7	-$13.4	-$8.1	-$7.1	-$18.3	-$32.9
3a	-$14.4	-$15.2	-$9.7	-$8.8	-$20.0	-$34.3
3b	-$13.2	-$13.4	-$9.0	-$8.1	-$18.8	-$32.4
4	-$14.8	-$15.5	-$10.2	-$9.2	-$20.3	-$34.5
5	-$13.3	-$14.4	-$8.8	-$7.7	-$18.9	-$33.1
6	-$14.6	-$15.4	-$9.8	-$8.7	-$19.8	-$33.5

Table 6-5 2035 Annual Profit/Loss (millions $2006) with Current Amtrak North of Charlotte

Case	HSR 90	HSR 110	HSR 125	HSR 150 Diesel	HSR 150 Electric	HSR 200
1	-$9.1	-$9.6	-$3.0	-$1.7	-$12.9	-$27.3
2	-$8.8	-$9.2	-$2.5	-$1.0	-$12.3	-$26.3
3a	-$11.2	-$11.7	-$4.8	-$3.5	-$14.6	-$28.4
3b	-$9.9	-$9.8	-$4.1	-$2.7	-$13.4	-$26.5
4	-$11.9	-$12.2	-$5.6	-$4.0	-$15.2	-$28.8
5	-$10.0	-$10.8	-$3.8	-$2.2	-$13.4	-$27.0
6	-$11.6	-$12.2	-$5.2	-$3.5	-$14.6	-$27.7

Table 6-6 2040 Annual Profit/Loss (millions $2006) with Current Amtrak North of Charlotte

Case	HSR 90	HSR 110	HSR 125	HSR 150 Diesel	HSR 150 Electric	HSR 200
1	-$6.5	-$6.9	$0.7	$2.3	-$9.0	-$23.1
2	-$6.2	-$6.5	$1.2	$3.0	-$8.3	-$21.9
3a	-$9.1	-$9.4	-$1.6	$0.1	-$11.1	-$24.5
3b	-$7.8	-$7.4	-$0.9	$0.9	-$9.8	-$22.6
4	-$9.9	-$10.0	-$2.5	-$0.6	-$11.8	-$25.0
5	-$7.7	-$8.4	-$0.5	$1.4	-$9.7	-$23.0
6	-$9.7	-$10.1	-$2.2	-$0.1	-$11.2	-$23.9

The figures below illustrate the shift toward operating profit over time for two of the cases considered, the maximum and minimum station cases with HSR in place north of Charlotte.

Figure 6-1 Operating Profit/Loss (2006 $)
Case 1 (All Stop Case) with HSR Extension

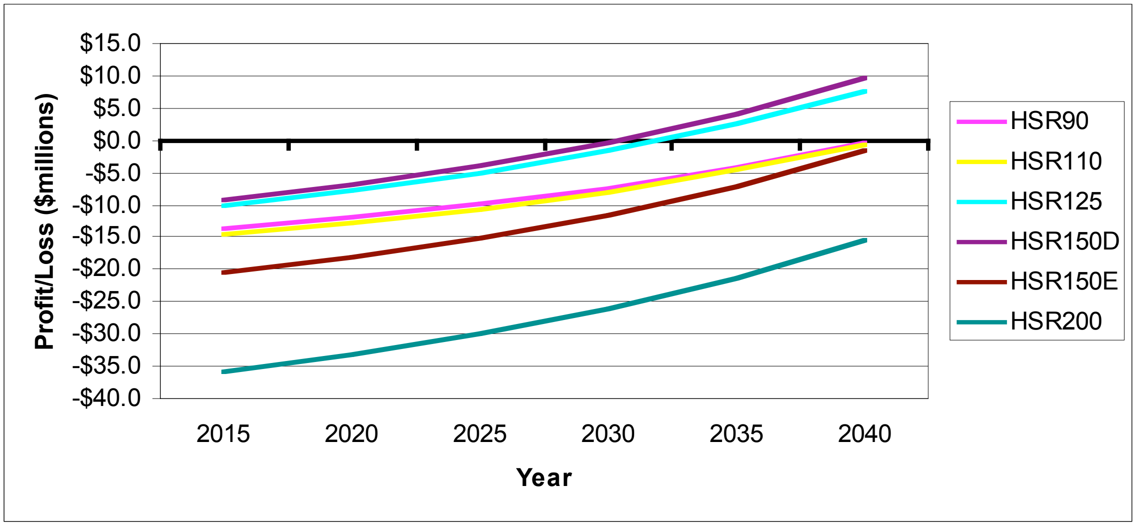
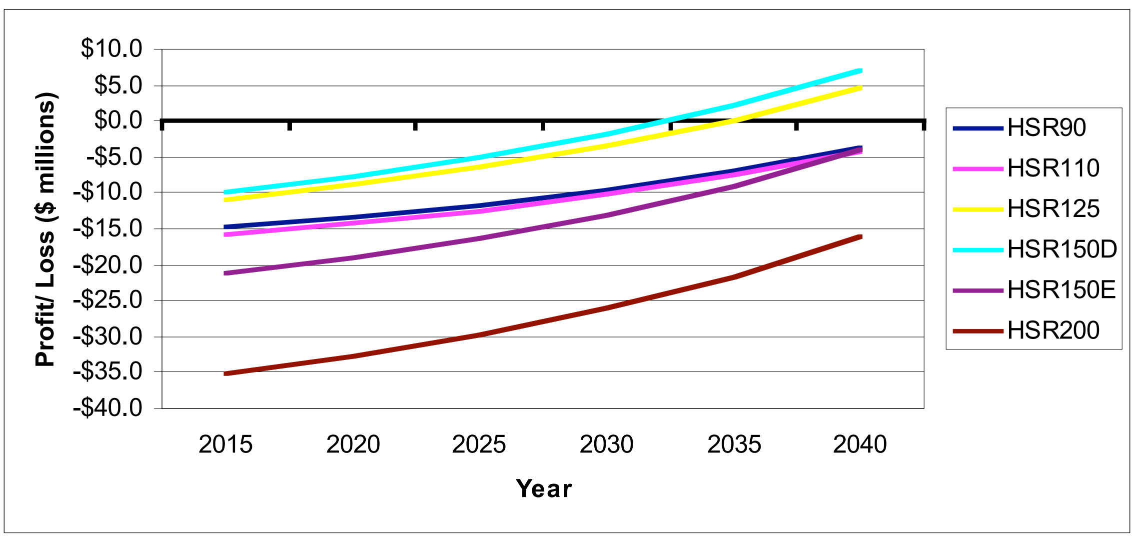


Figure 6-2 Operating Profit/Loss (2006 $)
Case 6 (Express 7-Stop Case) with HSR Extension



The analysis period covered the years 2015 to 2040. Ridership increases with the passage of time due to growth in population, income and travel in the corridor. Revenues increase as a function of ridership alone.

Increased ridership results in increased operating costs as well as increased revenues.

Operating costs increase as a function of train miles, route miles, train hours and ridership, within a given technology assumption. Within a given scenario train miles, route miles, and train hours are constant thus total operating and maintenance costs increase at a rate less than revenue as ridership increases. Average revenue/person is constant, while average cost/person is declining. As ridership grows over time revenues eventually exceed operating and maintenance costs.

6.3 Conclusions

The best case scenarios from an operating profit point of view are either the 125 mph or 150 mph Diesel HSR technology and improved rail service North of Charlotte.

Connection to the proposed HSR service Charlotte to Washington adds 80,000 to 100,000 trips per year within the Macon-Charlotte study corridor.

All technologies, routings and station stop alternatives investigated will require an operating subsidy in initials years.

The 150 mph diesel cases are projected to have an operating surplus starting after 2030, while the 125 mph cases would break even after 2035.

The final choice would have to balance passenger demand and revenues, operating costs, initial capital requirements and societal benefits.

7. SOCIAL IMPACTS ESTIMATION

7.1 Introduction

The study examined social impacts derived from physical and monetary changes due to ridership shifts among modes as indicators of the relative value of the social benefits of public investments.

These impacts included changes in air quality and energy use as a result of a shift from current modes to HSR, and consumer surplus (a user benefit similar to the estimated time or cost savings often cited in evaluating highway projects).

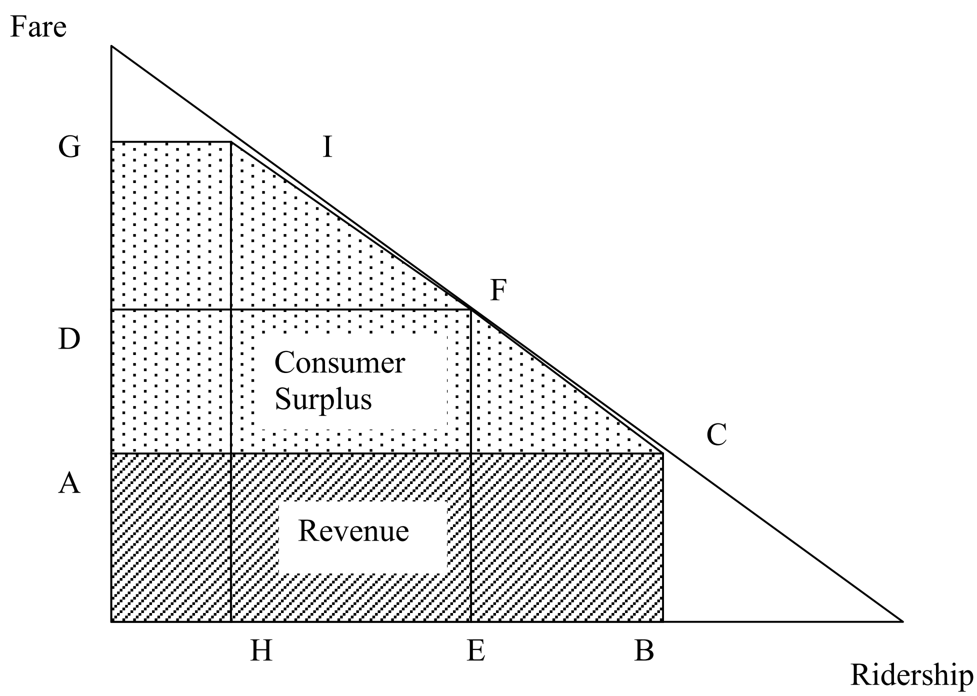
7.2 Consumer Surplus

The users' consumer surplus (CS) is the difference between the amount an individual would be willing to pay for HSR service and the amount demanded of her or him by the HSR operator. For example, a traveler might be willing to pay $25 for using HSR to go from City A to City B, but the HSR operator charges only $20 because that fare yields the maximum net revenue. The $5 difference is what economists traditionally call "consumer surplus".

For this study, the user' consumer surplus estimation procedure adopted the steps demonstrated in the Figure 7-1. Because the travel demand model is highly sensitive to fare levels (note downward slope of the diagonal line relating fares to ridership), increasing the fare from the base fare "A" to "D" and rerunning the model results in lower ridership ("E"). The lower number of projected HSR users represents the number of people who would be willing to pay the extra fare for the HSR benefits, and the added fare times the number of travelers willing to pay it represents the first increment of user' consumers surplus with respect to fare level "A." Increasing the fare again to "G" will result in even lower ridership ("H"). The new ridership times the fare increase from level "D" represents the next increment in users' consumer surplus. At some maximum point, the fare level is sufficiently high to discourage almost all riders and no additional increment of user' consumer surplus can be found. For purposes of this study, a maximum of three times the base HSR fare ("G" in the schematic) is used as the upper limit. By running the ridership model and increasing fares from the base level "A" to the upper limit, then summing up the increments in users' consumer surplus at each fare level, the users' consumer surplus can be calculated for each corridor and technology option."[1]

[1] *High-Speed Ground Transportation for America*, U.S. Department of Transportation, Federal Railroad Administration, September 1997, p. 6-5.

Figure 7-1 Users' Consumer Surplus Concept



The rectangles represent the value of CS to the then current rail users, while the triangles represent the value of CS to riders diverted/induced by the fare change[2].

In the example shown in the figure CS would equal

(D-A)*E + ½*(D-A)*(B-E) + (G-D)*I + ½*(G-D)*(E-H)

Starting with the base case fare assumption and resulting ridership level, CS was computed as the sum of the areas of a series of trapezoids under the demand curve as fare was increased in increments up to a level that was three times the base case fare level.[3]

CS was computed using various fare increments in an attempt to determine the best level of detail for the analysis, that is one that produced "acceptable" results (measured against the case of varying fare in 10% increments) versus computational work load. It appears that computing CS by increasing fares in 50% increments provides a good compromise

[2] *Estimating the Benefits and Costs of Public Transit Projects: A guidebook for Practitioners*, TCRP Report 78, Transportation Research Board, Washington, DC, 2002.

[3] This involves exercising the model under various assumed fare levels, transferring the ridership and fare level data to the CS computation template, adjusting for airport ridership that is determined off-line, computing CS for this fare increment, and then summing CS over all fare increments.

approach. This only involves computing CS based on four trapezoids, but provides a value that is within 3% of the CS estimate based on 20 trapezoids.

Consumer surplus was computed for all cases using the 50% fare increment indicated above. The results are indicated in the tables below for 2025. Results for 2015, 2020, 2030, 2035 and 2040 are in the Appendix.

In the 200 mph case 1 with HSR North of Charlotte the computed value of CS is about 65% of the estimated revenue of $29,240,000. In the 90 mph case the computed value of CS is about 62% of the estimated revenue of $20,170,000.

Table 7-1 2025 Consumer Surplus (2006 dollars)
Current Amtrak North of Charlotte

Case	Total Annual HSR 90 Consumer Surplus	Total Annual HSR 110 Consumer Surplus	Total Annual HSR 125 Consumer Surplus	Total Annual HSR 150 Consumer Surplus	Total Annual HSR 200 Consumer Surplus
1	$11,330,000	$11,630,000	$14,810,000	$16,090,000	$17,250,000
2	$11,250,000	$11,610,000	$14,840,000	$16,220,000	$17,500,000
3a	$9,102,000	$9,413,000	$12,160,000	$13,380,000	$14,570,000
3b	$9,485,000	$9,981,000	$12,330,000	$13,530,000	$14,780,000
4	$8,639,000	$8,969,000	$11,550,000	$12,760,000	$13,970,000
5	$7,286,000	$7,513,000	$9,981,000	$11,140,000	$12,290,000
6	$7,774,000	$8,026,000	$10,620,000	$11,930,000	$13,250,000

Table 7-2 2025 Consumer Surplus (2006 dollars)
HSR North of Charlotte

Case	Total Annual HSR 90 Consumer Surplus	Total Annual HSR 110 Consumer Surplus	Total Annual HSR 125 Consumer Surplus	Total Annual HSR 150 Consumer Surplus	Total Annual HSR 200 Consumer Surplus
1	$12,530,000	$12,890,000	$16,260,000	$17,650,000	$18,900,000
2	$12,450,000	$12,840,000	$16,290,000	$17,800,000	$19,190,000
3a	$10,280,000	$10,610,000	$13,580,000	$14,920,000	$16,220,000
3b	$10,660,000	$11,180,000	$13,750,000	$15,070,000	$16,430,000
4	$9,787,000	$10,150,000	$12,930,000	$14,250,000	$15,580,000
5	$8,441,000	$8,688,000	$11,370,000	$12,640,000	$13,910,000
6	$8,925,000	$9,197,000	$12,020,000	$13,390,000	$14,880,000

7.3 Air Quality and Energy Impacts

A model developed by Argonne National Laboratory (ANL)[4] for the CFS was used to estimate the net change in energy consumption and air pollutants due to the diversion of trips to the proposed HSR. The ANL modeling effort produced emissions and energy factors for the years 2000, 2010, 2020, 2030 and 2040. The factors were expressed in terms of grams/mile by mode for air pollutants such as CO, and BTU/mile for energy consumption. The emissions considered included HC (hydrocarbons - VOC, volatile organic compounds), CO (carbon monoxide), NO_x (nitrous oxides), SO_x (sulfur oxides), PM (particulate matter), and CO_2 (carbon dioxide). Load factor data by mode and data on the equivalent energy content of various fuels (e.g., gasoline) were also provided. Emissions and energy factors for electric powered trains were also provided. These were based on the mix of fuels used to produce the electricity on a regional basis.

The ANL data allowed us to estimate emissions and energy factors on a gram/passenger mile (PM) basis by mode (air, auto, bus and conventional rail). Factors for the years 2015, 2025, and 2035 were estimated by interpolation. The net change in emissions and energy use was estimated as the difference between the emissions (grams/PM) and energy use (BTU/PM) resulting from the diverted trips made by each mode in a given city pair before HSR in a given forecast year, and the emissions and energy use resulting from these same trips using HSR. Note that the emissions and energy use of HSR is dependent on the technology (e.g., 90 mph diesel locomotives vs. 200 mph electric locomotives). The HSR technologies include 90 mph diesel, 110 mph diesel, 125 mph diesel, 150 mph diesel, 150 mph electric, and 200 mph electric.

Results for changes in annual energy use and emissions as modeled by ANL depend on the specific city pair because each factor for rail and air modes includes both a fixed and variable component.

The results of the shift to HSR are not always positive due to the differing emissions and fuel use characteristics of each mode and technologies within the HSR mode. Negative values in the tables indicate a net increase in that pollutant or in energy use. Diverting 100 trips from auto to 150 mph diesel trains in one city pair does not result in the same change in emissions and energy use as diverting 100 trips from air to 200 mph electric trains in the same city pair. Thus little can be said a priori as to the likely outcome.

Results for Case 1, for the year 2025 are indicted below. Results for other years and other cases are in the Appendix.

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[4] Rote, Donald M., et al., *Methodology for Computing Public Benefits of Diverting Passenger Trips from Conventional modes to HSGT Modes of Travel – For Use with the FRA/DOT Commercial Feasibility Study*, Center for Transportation Research, Energy Systems Division, Argonne National Laboratory, May 5, 1995.

Table 7-3 Annual Reduction in Emissions and Energy Use Resulting from Shift to HSR - Case 1 with HSR North of Charlotte - 2025

Emissions (kg)							Energy Use (MBTU)
Technology	VOC	CO	NOX	SOX	PTM	CO2	
HSR 90	9,099	203,000	-38,900	-6,300	558	5,243,000	88,280
HSR 110	9,904	222,600	10,770	-1,960	1,052	6,839,000	84,640
HSR 125	11,760	280,700	-5,390	-4,770	750	7,073,000	95,910
HSR 150D	10,130	295,600	-54,100	-9,470	-1,010	4,450,000	93,680
HSR 150EL	16,930	313,900	71,890	-8,040	91	5,276,000	106,500
HSR 200EL	16,180	306,800	98,010	-11,000	-625	-6,800,000	-82,000

Table 7-4 Annual Reduction in Emissions and Energy Use Resulting from Shift to HSR - Case 1 without HSR North of Charlotte - 2025

Emissions (kg)							Energy Use (MBTU)
Technology	VOC	CO	NOX	SOX	PTM	CO2	
HSR 90	9,108	202,900	-32,400	-5,940	618	5,046,000	84,670
HSR 110	9,848	218,900	6,292	-2,300	1,047	6,466,000	83,620
HSR 125	11,720	276,200	-9,380	-5,100	725	6,496,000	94,900
HSR 150D	10,450	292,400	-51,700	-9,180	-798	4,219,000	93,560
HSR 150EL	16,310	308,200	57,260	-7,360	309	5,382,000	104,300
HSR 200EL	17,290	327,500	58,260	-10,100	-304	3,869,000	86,050

8. CONCLUSIONS AND RECOMENDATIONS

8.1 Conclusions

8.1.1 Routing

- All speed and station alternatives require a separate, dedicated passenger service track
  - The 90 - 125 mph cases will be single track with long sidings approximately every 25 miles
  - The 150 - 200 mph cases will require double track dedicated to passenger rail service
- An alternative route following I-75 south of Hartsfield Airport would save 15 miles, and 20 minutes @ 90 mph, between the airport station and Macon. This would require the elimination of the Griffin stop and save approximately $140 M in capital costs
- Dropping one or two stations impacts total trip time by only average of five minutes per station dropped
- Eliminating Toccoa or Greenville Spartanburg International Airport will not significantly impact trip time
- Significant time savings using the express routing Case 6, especially with I-75 routing option (saves 47 minutes over the all-station stop case - Case 1)

8.1.2 Costs

- Annual O&M costs range from about $30M to $60M
- O&M costs assume a new, independent operating authority with an efficient organizational and staffing structure
  - Our estimates are lower than those of other recent studies
- Estimated capital construction and vehicle acquisition costs for the entire corridor range from about $1,800 million for the 90 to 100 mph cases to $3,400 million for the 150 mph electric and 200 mph cases
- For example, the total amortized annual expenditure for initial capital over a 40-year horizon at government borrowing rates for the 125 mph technology option would be about $120 M per year
- Major difference between 2003 SEHR study and current study ($180 M) due to increased estimate for ROW costs in Atlanta to Charlotte corridor
- Using I-75 alignment rather than NS corridor results in $114 M potential saving
  - Save 15 miles of construction
  - ROW costs could be up to $100 M less
- Upgrading from 110 to 125 mph increases total capital investment by $310 M
- Electrifying whole corridor costs roughly $700 M

8.1.3 Ridership

- Estimated ridership in 2025 ranges from 660,000 one-way passengers for the express (7-station) case using 90 mph technology and with existing rail service north of Charlotte; to 1,190,000 for the all-stop (14-station) case using 200 mph technology with HSR north of Charlotte
- System revenues range from $12.7 M to $29.2 M annually
- Estimated ridership and revenues decrease as stations are eliminated within any given technology assumption, as shorter access/egress had greater influence on demand than decreased linehaul travel times

8.1.4 Financial

- All technologies, routings and station stop alternatives investigated will require an operating subsidy in initials years
  - The 150 mph diesel case will have an operating surplus starting after 2030, and the 125 mph case after 2035
  - The 90 mph 110 mph, 150 mph electric and the 200 mph technologies were found to require subsidies for the entire analysis period through 2040
- Connection to new HSR service Charlotte to Washington adds 80,000 to 100,000 trips per year within the Macon-Charlotte study corridor
  - Improved connections at Charlotte, including through train service, would increase corridor ridership
  - Additional ridership would also result from adding rail connections to Florida, the Gulf Coast and Tennessee

8.1.5 Best Case

- The best case scenario is either the 125 mph or 150 mph Diesel HSR technology with 14 station stops in the corridor and improved rail service North of Charlotte
  - Balances passenger demand and revenues, operating costs and initial capital requirements

	125 mph	150 mph (Diesel)
Travel time	4:05	3:36
Capital costs	$2,060 M	$2,520 M
Passengers (2025)	1,077,000	1,142,000
Revenues (2025)	$27.0 M	$29.1 M
O&M costs (2025)	$32.0 M	$33.1 M
Profit/loss (2025)	($5.0 M)	($4.0 M)
Break even year	2032	2031

8.1.6 Public Private Partnership

- The Southeast High Speed Rail project proposed a Public Private Partnership (PPP) for development and provision of passenger rail service between Charlotte, NC and Macon, GA
  - Government would provide and own the infrastructure
  - A private rail operator would run the rail service in the corridor without need for continuing subsidy
- Numerous forms that PPPs could take, depending on the degree of separation and organizational freedom desired
- Types of PPP Models
  - Operator provides a specified service for a fixed fee
    1. Frequency and fares fixed by the contracting authority
    2. Revenues taken in by contracting authority
    3. Performance measurements for service quality
    4. Risk for poor ridership and low revenues borne by contracting authority
    5. Contractual penalties (or incentives) based on service quality
    6. Examples: Domestic commuter agencies
  - Operator has greater decision flexibility and takes more financial risk
    1. Minimum level of service established in the contract
    2. Operator may vary service (frequencies, fares, consists) based on business principles
    3. Revenues taken in by operator
    4. Risk for business performance is with operator
    5. May involve a minimum revenue guarantee to operator
    6. Used throughout Europe: England, Sweden, France

- Does the size and scope of the SEHSR Corridor support the establishment of two distinct organizations, for train operation and infrastructure?
- Amtrak as the Operator?
  - Experience operating similar state-supported corridor services
  - Might improve interoperability between the SEHSR and the rest of the National Train System
  - Maintenance of equipment, reservations, and marketing functions already established
  - Some Amtrak “inefficiencies” are being resolved over time

8.2 Recommendations

- Need to develop a political consensus concerning innovative approaches to pay for capital costs and initial operating deficits
  - Results indicate that there would not be sufficient operating surpluses to finance capital cost bond payments
  - A dedicated funding source, e.g., a sales tax increment, might be required
- Consider the plusses and minuses of partnering with Amtrak to upgrade their existing corridor services
  - Synergies might lower some costs, e.g., for marketing, reservations, etc.
  - Current Federal Congress has pending legislation to fund Amtrak expansion
- Pursue closer ties with nearby States planning potential rail expansions
  - Networked systems result in significant additional corridor ridership and might make higher speed alternatives feasible
- Freight railroads are potential supporters of passenger rail expansion if new and existing passenger rail service were shifted to separate (parallel) track easing freight congestion
- Additional rail planning should probably focus on the 125 mph and 150 mph diesel technologies
  - Have the best chance of financial viability within this corridor, and are most compatible with the proposed rail enhancements North of Charlotte

ACRONYMS

AAA	Automobile Association of America
ANL	Argonne National Laboratory
BTS	US Department of Transportation Bureau of Transportation Statistics
BTU	British Thermal Unit
CFS	Commercial Feasibility Study
CS	Consumer Surplus
CSX	CSX Transportation, a class 1 railroad
FRA	US Department of Transportation Federal Rail Administration
FAA	US Department of Transportation Federal Aviation Administration
GDOT	Georgia Department of Transportation
GSP	Greenville-Spartanburg International Airport
HSR	High-speed rail
HSGT	High-speed ground transportation
IHSR or Accelerail	Incremental high-speed rail
ISTEA	Intermodal Surface Transportation Efficiency Act
LOS	Level of service
MARTA	Metropolitan Atlanta Rapid Transit Authority
MMPT	Multi-Modal Passenger Terminal
MOU	Memorandum of Understanding
mph	Miles per hour
MPO	Metropolitan planning organization
MSA	Metropolitan statistical area
NEC	Northeast Corridor
NS	Norfolk Southern Railway
OAG	Official Airline Guide
O/D	Trip origin to trip destination
O&M	Operating and maintenance costs
PM	Passenger mile
PPP	Public Private Partnership
ROW	Right-of-way
SEC	Southeast Corridor
SEHSR	Southeast High-Speed Rail study
TAF	FAA's Terminal Area Forecast
TEA-21	Transportation Equity Act for the 21st Century
TPC	Train Performance Calculator
TRB	National Research Council Transportation Research Board
USDOT	US Department of Transportation
VMT	Vehicle miles travelled