SOUTH CAROLINA
SOUTHEAST HIGH SPEED RAIL
CORRIDOR IMPROVEMENT STUDY

prepared for the

South Carolina Department
of Transportation

by

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in association with

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TABLE OF CONTENTS

TABLE OF CONTENTS

EXHIBITS

EXECUTIVE SUMMARY

The Southeast Rail Corridor was originally designated as a high-speed corridor in Section 1010 of the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991. More specifically, it involved the high-speed grade-crossing improvement program of the Act to reduce or eliminate the hazards of at-grade rail-highway crossings in the designated corridors. At that time, the Southeast Rail Corridor was one of five so designated, and was to connect the southern end of the Northeast Corridor to Charlotte, North Carolina.

South Carolina Routes

The high-speed rail grade crossing improvement program was carried over into the Transportation Equity Act for the 21st Century (TEA-21) as Section 1103(c). Subsequently, the Southeast High-Speed Rail Corridor (SEHSR) was extended in December 1998 south from Charlotte to Atlanta and Macon, Georgia running through the Upstate of South Carolina. Another branch was added running through Columbia to Savannah, Georgia and Jacksonville, Florida from Raleigh, North Carolina. The Corridor was further extended in October 2000 from Macon to Jessup, Georgia, tying the two branches together. The current Southeast High-Speed Rail Corridor is shown in Exhibit E-1.

The two branches, or routes in South Carolina are comprised of two existing rail lines. The first is the Norfolk Southern Railway (NS) main track running through the Upstate, a heavily used line (high freight density plus Amtrak's *Crescent*) and one of the railroad's core system routes. The other is the CSX Transportation (CSXT) "S" Line running north-south through the center of the state. It is a secondary main north of Columbia although it is home to Amtrak's *Silver Star*, but the segment of the line south of Columbia has been designated a premium service route by CSXT.

An August 1997 study by KPMG Peat Marwick determined that the selected corridor serves a greater population base than other routes within the area. On April 30, 1999, the SCDOT Transportation Commission passed a resolution in support of the SEHSR Corridor with extensions to Charleston and to Myrtle Beach. The SCDOT has since made requests for further

Exhibit E-1

high-speed rail designations along the South Carolina coast; however, the Federal Railroad Administration requires further study be performed. To date these studies have not been funded.

Corridor Development

Planning and development of the Corridor is being guided by a four-state coalition – Virginia, North Carolina, South Carolina and Georgia. While each state is currently pursuing individual rail programs, the four states are united in their desire to link the programs to develop a truly regional high-speed rail system. The goal of the four-state consortium in developing the SEHSR is a top speed of 110 mph. This study and plan is South Carolina's initial examination of the physical feasibility of high-speed passenger rail service in the state.

Federal funds in the amount of $200,000 from the current appropriation bill have been designated to study upgrades required in that section of the SEHSR Corridor from Charlotte to Atlanta. The SCDOT is currently trying to determine a source for the 50 percent match required for its share of the project cost.

Route Conditions

The Central Route is 205 miles long in South Carolina. It is a single-track line with a traffic control signal system operated at top speeds of 60 miles per hour north of Columbia and 79 miles per hour south of Columbia. Top speeds are restricted due to curvature over all of the route except the last 70 miles. It is used by a limited amount of freight trains and Amtrak's *Silver Star.*

The Upstate Route runs for 122 miles in South Carolina. The line has alternating single and double track in the same approximate amounts with a traffic control signal system. The top permissible operating speed is 79 miles per hour, but that is not obtainable over most of the route due to curvature. Amtrak's *Crescent* operates over the line and it is heavily used by freight trains.

Route Improvements

Improvements in the routes are necessary for higher speed trains and to increase capacity in addition to at-grade rail-highway crossing modifications. On the **Upstate Route**, improvements would consist primarily of those needed for capacity if the existing alignment is used for the proposed service. Speed-related improvements would comprise efforts to increase the average operating speed, not the top speed. Land development in the Upstate precludes major alignment changes along the line. A new alignment would be required to reach the target operating speed of 110 mph. Most of the cost of grade crossing improvements is attributable to grade separations as the route already has a high level of active warning devices.

The **Central Route** holds more promise for attaining the target speeds. Major realignments north of Columbia are required, but the effort is lessened south of Columbia with almost 70 mile of near tangent track. Also required would be reconstruction of the track, major modifications to the signal system, and construction of several new passing tracks along with the extension of existing ones to add capacity. The route requires a significant increase in active warning devices for the grade crossings in addition to closures and separations.

Order-of-magnitude improvement costs total $145 million for the Upstate Route and $742 million for the Central Route. These costs will be refined as planning and engineering progress.

Not included in the improvement costs is rolling stock. In order to make significant speed improvements, especially on the Upstate Route, tilting equipment will be required. Tilt equipment permits increases in speeds through curves without sacrificing passenger comfort. No costs are included at this time as it is assumed the expenditures will be shared by the Coalition in an yet undetermined manner.

Charlotte – Columbia

The Norfolk Southern line between Charlotte and Columbia was subjected to a cursory examination as a potential Corridor connector or alternative alignment. It was found to have similar characteristics to the Upstate Route with a little more curvature. Operations over the line are controlled by an automatic block signal system and top operating speeds are now 50 mph. The line does not have any passenger service and its freight traffic is growing. Without major realignment, the route would at best be a 79-mph railroad, even with tilt equipment.

Chapter 1
BACKGROUND

As part of its multimodal approach to statewide transportation, the South Carolina Department of Transportation has begun to seriously consider rail passenger transportation as a concept component. High-speed rail passenger transportation is considered by many as a critical element of the package if rail transportation is to become a viable alternative. The Southeast High-Speed Rail Corridor, a regional proposal, provides a promising initiative.

Authority

The Southeast Rail Corridor was originally designated as a high-speed corridor in Section 1010 of the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991. More specifically, it involved the high-speed grade-crossing improvement program of the Act to reduce or eliminate the hazards of at-grade rail-highway crossings in the designated corridors. At this time the Southeast Rail Corridor was one of five so designated, and was to connect the southern end of the Northeast Corridor to Charlotte. The high-speed rail grade crossing improvement program was carried over into the Transportation Equity Act for the 21st Century (TEA-21) as Section 1103(c). Subsequently, the Southeast High Speed Rail Corridor (SEHSR) was extended in December 1998 south to Atlanta and Macon, Georgia, and through Columbia to Savannah, Georgia and Jacksonville, Florida.

Southeast High Speed Rail Corridor

Planning and development of the Corridor is being guided by a four-state coalition – Virginia, North Carolina, South Carolina and Georgia. While each state is currently pursuing individual rail programs, the four states are united in their desire to link the programs to develop a truly regional high-speed rail system.

The SEHSR Corridor in South Carolina is actually comprised of two branches as shown in Exhibit 1-1. The first is the Norfolk Southern Railway (NS) main track running through the

Upstate, a heavily used line (high freight density plus Amtrak's *Crescent*) and one of the railroad's core system routes. The other is the CSX Transportation (CSXT) "S" Line running north-south through the center of the state. It is a secondary main north of Columbia although it is home to Amtrak's *Silver Star*, but the segment of the line south of Columbia has been designated a premium service route by CSXT.

Connecting Corridors

Three additional corridors were announced in TEA-21, and the U.S. Secretary of Transportation has the authority to add three more. This authority was exercised in October 2000, with the addition of two new corridors for a total of 10 designated high-speed rail corridors. In addition, new routes extending or connecting previously designated corridors were also included. Of particular interest to this effort is a Birmingham–Atlanta, Gulf Coast-Southeast Corridor connection, and a Macon-Jessup, Georgia extension of the Southeast Corridor. This latter addition ties the two SEHSR Corridor routes together. Exhibit 1-2 depicts all designated corridors and extensions which total 8,306 miles in length and are located in 30 states. The original ISTEA 1010 Corridors totaled 2,600 miles in length.

Eligibility

To be eligible for designation under this legislation, speeds of at least 90 mph should be occurring or expected to occur in the future. The goal of the four-state consortium in developing the SEHSR is a top speed of 110 mph.

Study Purpose

At present, Virginia and North Carolina are ahead of South Carolina in corridor development plans although work sponsored by those states, and some jointly performed, has involved corridor segments in South Carolina. This study and plan is South Carolina's initial examination of the physical feasibility of high-speed passenger rail service in the state.

The work effort follows federal guidelines and the plan includes three components:

- ?? A long-range comprehensive plan (15-20 years);
- ?? A six-year plan; and
- ?? An immediate plan.

For each of the plans above, improvements needed for both the operation of high-speed passenger trains and grade crossing hazard mitigation/elimination are identified, tabulated and capital costs estimated.

Concept

The designated corridors are to be capable of being operated at speeds of at least 90 mph, with a goal of 110 mph. Attainment of these higher than conventional speeds will require improvement of the designated rail lines in the state in terms of physical condition, signaling, alignment and safety (protection of right-of-way and grade-crossing conflicts). Each Corridor segment was examined to determine the extent of improvements required to increase speeds and at what level they are likely to be maintained.

As the target maximum speed of 110 mph exceeds the original design parameters of both routes on which 4 and 5 degree curves are common and limit conventional passenger equipment speeds to 45 – 55 mph. Given existing conditions, the use of tilt trains for the Corridor was adopted. Tilt trains provide more passenger comfort on curves permitting a speed range of 55 – 75 mph for 4 to 5 degree curves.

Data Collected

Data collected for the study was obtained principally from the SCDOT and the two rail carriers which own the rail lines being evaluated. Data obtained are listed below:

- ?? South Carolina Department of Transportation grade crossing inventory;
- ?? Additional SCDOT traffic volume data where necessary;
- ?? SCDOT county highway maps;
- ?? USGS topographic maps (1:24,000);
- ?? Railroad track charts, timetables, traffic density maps;

?? Previous Corridor studies including those performed by other SEHSR states; and

?? Aerial and ground reconnaissance.

Study Process

A general description of the characteristics of each rail line and the predominant environments through which they pass was prepared from both primary and secondary data sources. This description also lists the inherent advantages and/or disadvantages each route possesses for attainment of operating goals. Once the data had been obtained, the following actions were taken/products produced.

1. A listing of existing public and private at-grade crossings with a warning and safety device characteristic inventory. SCDOT inventories of both public and private crossings were field checked for items of interest to this study, but not to the extent as to fully update of the state's inventory.

2. A determination of existing speed limitations in each route was made from railroad timetables and track charts.

3. General track structure condition was determined as were improvements required to reach the level of intended operating speeds.

4. An assessment of signal system (train control) deficiencies was also made, again based on the levels of intended operation. Warning devices at rail-highway at-grade crossings were also upgraded as recommended in the plan.

5. Potentials for disruptions to social, natural or ecological systems (of a preliminary nature) by alteration of the routes were considered where applicable.

Chapter 2

ROUTE SEGMENT IMPROVEMENTS

The routes through South Carolina comprising the SEHSR Corridor were examined and their potential to meet Corridor goals determined. Needed improvements were identified and quantified.

ROUTE SEGMENTS

The designated corridor routes in South Carolina are single-line rather than multiple line corridors in that a single rail line is located within each. For the purposes of this study, the two legs of the SEHSR Corridor are designated as the Central and Upstate Routes. The Central Route is home to CSXT's "S" Line, the main line of the former Seaboard Air Line Railway. The Upstate Route is home to the Washington, DC-Atlanta, GA main line of NS.

Central Route

The "S" line is 205.3 miles long from the North Carolina – South Carolina state line to the Georgia border at the Savannah River. The route passes through Cheraw, Patrick, McBee, Bethune and Camden before reaching Columbia and heading almost due south through Swansea, North, Norway, Denmark, and Fairfax en-route to Savannah (see Exhibit 2-1).

Line Use – In addition to the passenger train which runs in each direction daily, Amtrak's *Silver Star,* the line functions as a secondary main line for CSXT freight operations. Freight operations average 3-5 trains per day north of Fairfax and 12-13 south of Fairfax with the addition of trains to and from a connecting CSXT line.

Train Control – Operations on the line are governed by a traffic control signal system (TCS) with block signals authorizing train movement.

Track Characteristics – The line is basically single-track with dispatcher controlled sidings located 15 to 35 miles apart. The track is constructed of steel rail with mixed hardwoods

on crushed stone ballast. Rail weights are as follows, and approximately follow the order shown from north to south.

- ?? 28.9 miles of 112-lb.welded rail
- ?? 31.2 miles of 115-lb. jointed rail
- ?? 84.7 miles of 115-lb. welded rail
- ?? 31.0 miles of 131-lb. welded rail
- ?? 29.5 miles of 132-lb. welded rail

Operating Speed – North of Columbia, the maximum permissible speed for passenger trains is 60 mph. It is believed the speed is restricted due to the lighter rail weights and the non-welded segment. It is further restricted, principally to 50-55 mph, in many locations and 40-45 mph in some locations due to curvature. Two to four degree curves are common.

The operating speed is restricted to 30-40 mph through Columbia, approximately four miles.

South of Columbia, the maximum permissible speed for passenger trains increases to 79 mph. Curvature again restricts operating speeds between Columbia and Norway (40 miles), but south of Norway there are only eight curves, and the few restrictions that do exist are not a result of curvature, but rather municipal ordinances

Upstate Route

The NS line in South Carolina is 122 miles long from the North Carolina to the Georgia border. It traverses the industrialized Piedmont section of the state running through the communities of Blacksburg, Gaffney, Spartanburg, Greer, Greenville, Easley, and Clemson as shown in Exhibit 2-1.

Line Use – The route is a very heavily used segment of NS's mainline line system. Eighteen to twenty freight trains per day are joined by Amtrak's daily *Crescent*.

Train Control – The NS line is traffic control (TC) and remote control territory meaning a dispatcher controls routing on the line which is alternating double and single track. The former double-tracked line was reconfigured with the installation of TC and the second track removed every other 10 miles or so several decades ago.

Track Characteristics - The trackage through South Carolina currently is comprised of 64 miles of double track and 58 miles of single track. The entire route is laid with 132-lb. welded rail.

Operating Speeds – The maximum permissible speed for passenger trains over the line is 79 mph. Very little of the line is operated at this speed, however, due to the presence of multiple curves. In fact, only 6.6 miles of the route in South Carolina can be operated at the maximum permissible speed. Curvature is not the only factor limiting speed, however, as there are also restrictions at grade crossings, one stretch without electric locks on mainline turnouts, and mainline equilateral turnouts at the single track – double track junctions.

Compatibility of Existing and Proposed Corridor Operations

Rail freight and rail passenger services have very different operational characteristics, needs, and priorities. As long as the same railroad and decision-makers are involved, as long as traffic densities are not too great, and as long as train speeds are within a reasonable range, these interface issues can usually be handled. However, as density builds, as the number of entities (with different priorities) involved in decisions increases, and especially when higher speed trains are introduced creating a wider speed gap with existing operations, the interaction between the two types of railroad operation becomes more complicated and, in some corridors, prohibitive.

The interaction problems range from curve elevation (superelevation) and overhead clearance issues (catenary); to operational priorities and capacity problems; and, finally to infringements and tradeoffs from a service standpoint. If enhanced rail passenger services are to coexist with rail freight services, and especially if they are to use the same track, tradeoffs will have to be developed and considered. Precedents may well have already been set in other states, e.g., the terms of the renewed NS lease of the North Carolina Railroad which limits passenger train operations to 90 mph on the same track as NS freight operations, and calls for a separate track for higher speeds.

Regulations and Guidelines – Exhibit 2-2 (following page) depicts federal regulations and guidelines governing permissible passenger train operating speeds. Governing factors consist of both track condition as measured by Federal Railroad Administration Track Safety Classifications, train control (signal) systems, and rail-highway crossing characteristics. Corridor plans were developed around those regulations and guidelines for the 79 – 110 mph category.

Physical Conflicts – One of the physical problems relates to superelevation of curves. The high-speed passenger service will require greater elevation in curves than freight trains need, even considering authorized "unbalanced" elevation. Another physical problem relates to the level of maintenance (FRA track class) required for high-speed trains and the related maintenance problems created by "tonnage" freight trains. Similarly there will be overhead clearance issues if the passenger system were electrified, etc. The differential in operating speeds with high-speed passenger trains also impacts wayside signals as well as grade crossing warning devices and related circuitry. Problems were identified, defined and considered in formulating the approach to development of the SEHSR Corridor in South Carolina.

CORRIDOR IMPROVEMENTS

The two routes were assessed using railroad track charts, timetable data, USGS quadrangle maps and field reconnaissance, both aerial and on-the-ground.

Speed Limitations

The initial effort used track chart and timetable data to identify existing speed limits. Maximum permissible speeds are governed by safety regulations (see Exhibit 2-2) pertaining to the type of train control system and track class. Both routes have a maximum permissible speed of 79 mph which is typical of most rail lines over which passenger service is operated. There are only a few lines in the United States with higher speed limits, the most notable of which is the Northeast Corridor.

Exhibit 2-2
REGULATIONS AND GUIDELINES GOVERNING PERMISSIBLE OPERATING SPEEDS

Speed Range	Characteristics (Examples)	Train Control	Other Right-of-Way
AConventional@ up to 79 mph	Typical Amtrak service provided on most of the national route system. FRA Class 4 track.	Automatic block signals, centralized traffic control.	Active and passive at-grade rail-highway crossing warning devices.
AImproved Conventional High Speed@ 79-110 mph	Requires cab signals, and may require train stop or train control, under current regulations. Existing service: Amtrak service on several railroads in cab signal territory. FRA Class 5 and Class 6 track.	Continuous cab signals which provide a display of train-control signals in the locomotive cab, auto-matic train stop or train control systems for automatically controlling train speed and stopping trains.	Minimize number of at-grade crossings and increase number of active warning devices where possible. Detectors for failed bearings, slides, etc.
AAdvanced High Speed@ 110-125 mph	Not permitted under existing FRA Track Safety Standards, except by waiver. Existing service: Metroliner service on the Northeast Corridor between Washington and New York. Maximum speeds for diesel-electric and turbo trains.	Continuous cab signals with automatic train control and positive stop.	At-grade crossings not permitted unless research demonstrates effectiveness of barrier/detector. Plus explore sensors for bridges, fencing where warranted; limit freight traffic to off hours where possible.
AVery High Speed@ 125-150 mph	Speed range of all-electric trains and effective use of tilt equipment.	Plus protection for temporary slow orders.	At-grade rail-highway crossings not permitted. Plus comprehensive incursion plan; freight limited to off hours.
"Super High Speed" 150-250 mph	Only the French TGV (to 200 mph), the German ICE (to 156 mph), and the Japanese Shinkansen (to 168 mph) currently operate revenue service in this range.	Plus protection for temporary slow orders.	At-grade rail-highway crossings not permitted. Plus dedicated right-of-way (no freight or other traffic).
AUltra High Speed” >250 mph	Maglev and third generation steel-wheel-on-steel-rail equipment.	Plus protection for temporary slow orders.	At-grade rail-highway crossings not permitted. Plus dedicated right-of-way (no freight or other traffic).

Source: Federal Railroad Administration

Restrictions – Typically railroad speed restrictions[1] fall into these general categories:

?? Governmental ordinances;
?? Turnouts/Crossovers;
?? Curvature; and
?? Others (yard limits, at-grade crossings of other railroads, bridges, and tangent track between restricted curves).

While restrictions in virtually all of the categories exist on the designated routes, the most prevalent is due to curvature, and for that reason, it is discussed in some detail in the following paragraphs.

Curvature – Curves present both safety and passenger comfort issues. The speed at which a passenger train may negotiate a curve without causing discomfort to passengers or climbing off the track is determined by two things – 1) the degree of curvature (the measure of the sharpness of the curve), and 2) the amount of superelevation (the measure of how much the outer rail is raised or "banked" above the inner rail to compensate for the lateral force of gravity encountered in a curve).

Since trains are longer, heavier, and have higher centers of gravity than say, automobiles, railroad curves are usually longer and flatter than highway curves, but the principle is the same. As with other kinds of moving vehicles, the safe speed going around a curve – that is, a speed less than the overturning speed – is higher than the limits imposed by comfort. So, one of the principal reasons for superelevating curves, in addition to preventing overturning of vehicles, is to ensure passenger comfort. If it were not for the impact of lateral "G" forces[2] on the human body, vehicles could go around curves at speeds much higher than they do. Eventually, of course, a train will turn over or climb off the track if the speed is high enough and the curve sharp enough. So, superelevating a curve both increases the maximum safe speed and provides rider comfort.

[1] A restriction being an operating speed less than the maximum permissible for a line segment.
[2] Force exerted by gravity on a body at rest and used to indicate the force to which a body is subjected when accelerated.

There are two elements of superelevation which are used in determining permissible train speeds – 1) actual and 2) unbalanced. In American railroad practice, actual physical superelevation does not exceed six inches (and typically lower, 4 to 5 inches, on freight railroads). Greater superelevation than this produces higher maintenance costs, and interferes with the economical operation of freight trains and thus, with freight trains being the predominate user of U.S. main tracks, the actual superelevation is typically less than the maximum. This practice permits freight trains to traverse curves at equilibrium speeds.[3]

Conventional passenger trains can generally operate around curves at speeds in excess of equilibrium speeds, without impairing safety or comfort. For conventional passenger trains operating in the United States, the degree to which trains can exceed the equilibrium speed is the equivalent of three inches of "unbalance," or non-existent superelevation. That is, on a typical main line railroad curve, the superelevation required for "equilibrium" at the target operating speed is three inches more than the actual physical superelevation. "Unbalance" is also sometimes called "cant deficiency," an English railroad engineering term that describes what is missing; namely, the amount of additional superelevation of the outer rail that would be needed to restore equilibrium. Tilt equipment, however, provides a comfortable ride at greater imbalance, and thus a greater "cant deficiency" and a corresponding higher speed is permitted.

Speed Enhancement

Once the speed restrictions on the study routes had been identified, means to eliminate or mitigate them were considered. A phased program to address potential solutions in ascending order of complexity was derived.

Enhancement Cases – In all, four levels of speed enhancement were developed. A fifth case used in the analysis, the base case or existing conditions, served as a basis for comparison for the enhancement cases. The cases are defined in Exhibit 2-3. In all cases, appropriate train control system modifications are also to be made to permit the possible speeds.

[3] Equilibrium speed is the speed through a curve at which the superelevation is exactly enough that the centrifugal force pushing out is balanced against the gravitational force pulling in. In other words, the weight-to-force distribution is equal on both rails and, thus, on ties and ballast, i.e., no "creeping" or loss of gage.

Exhibit 2-3
ENHANCEMENT LEVELS

CASE	DESCRIPTION
1	Base
2	Remove city ordinances, add electric locks, etc.
3	Case 2 with 6 inches of cant deficiency
4	Case 3 with curve realignments
5	Case 4 with route changes

The first level of enhancement (Case 2) is comprised of items more easily accomplished then intensive capital projects with long lead times for engineering and permitting. Included in this category are replacement of equilateral turnouts with right/left-hand turnouts (permitting a faster speed on the non-diverging side), installation of electric locks on turnouts that do not have them, and lifting municipal restrictions. The latter may well be accompanied by grade crossing warning device improvements.

The next level (Case 3) would result from the use of tilt train equipment on the routes. Needless to say, significant levels of investment would begin here.

The last two cases, 4 and 5, involve improvements in the alignment of the existing rail lines. In Case 4,only curves are realigned to reduce the degree of curvature permitting an increase in operating speeds. In Case 5, relocations of line segments were examined in several locations where multiple curves could be lightened or eliminated at one time. Proposed alignment changes were planned using USGS quadrangle mapping, and available aerial photography. The potential improvements were field checked by air for bcational feasibility followed in some cases by ground reconnaissance.

Enhancement Case Results –The contemplated improvements were put into place for each case and the results measured in train operating times (theoretical running time) given the new permissible speeds and the applicable distances to which they apply. The measurement was made by computing a time to traverse each route segment by dividing the segment length by the permissible speed. The results are the subject of Exhibit 2-4. No train simulations[4] were performed, therefore, acceleration and deceleration impacts are not accounted for in the theoretical running time. These impacts vary according to the number of times speed has to be changed and the severity of the change, but would tend to lower average speed and thus increase running time.

Exhibit 2-4
ALTERNATE IMPROVEMENT PLAN RESULTS

		Case				
Route	**Item**	**1**	**2**	**3**	**4**	**5**
Central (CSXT) (206 mi)	TRT (min)[1]	197.0	195.3	151.4	144.2	128.8
	AS (mph)[2]	62.7	63.2	81.5	85.6	95.8
	IMP (min)[3]		1.7	43.9	7.2	15.4
Upstate (NS) (122 mi)	TRT (min)[1]	127.4	125.2	98.2	92.1	87.7
	AS (mph)[2]	57.4	58.4	74.5	79.4	83.3
	IMP (min)[3]		1.9	27.3	6.1	4.4

(1) Theoretical Running Time – Based on permissible speed per segment of each route.
(2) Average Speed – Length of line segment divided by permissible speed over which speed limit applies.
(3) Improvement – Incremental difference in theoretical running time from case to case.

As evident from review of the table, there is very little change in the running time between Case 1 and 2 as locations are limited and short distances are involved. Based on prior experience, however, removal of the restrictions in Case 2 are more productive than indicated when the time lost in reducing and resuming operating speeds at each location is considered.

Significant changes resulting from the use of tilting rolling stock are evident between Cases 2 and 3. A quick review of the remainder of the table reveals that this one action produces the biggest result of any of the improvement methods.

The curve realignments in Case 4 are not real productive, but here again would prove to produce better results once acceleration and deceleration are considered. The results show more potential for the Upstate Route than for the Central Route on a per-mile basis.

[4] A computer program which simulates the operation of a specified train consist (motive power and passenger cars) over a rail route with specified alignment and gradient characteristics at permissible speeds.

The route segment realignments in Case 5 appear to produce mixed results for the two routes. The effect has little impact on the Upstate Route but holds greater promise for the Central Route. In fact, on a per-mile basis, it is even more effective as most of the realignments are located on the north end of the segment.

Enhancement Implications – The results of the improvement scenarios imply that the use of tilt equipment holds the most promise for significant speed increases and corresponding running time decreases. Increases in either real or unbalanced track superelevation would enhance the option, both of which would have negotiated with the owning railroad and in the latter case, the FRA.

Minor curve realignments hold some promise on the Upstate Route while route segment realignments do not. Based on field and air reconnaissance, the proposed major route realignments would be difficult to implement anyway due to the level of development along the railroad for most of its route through the state. Thus, the most realistic approach to Upstate Corridor speed-related improvements appear to be the use of tilting rolling stock with selective curve realignments, the latter to be performed only where truly effective (see recommendations in Chapter 4).

The long segments of tangent track on the south end, and the potentially successful segment realignments on the north end, hold promise to meet the target speeds on the Central Route (see recommendations in Chapter 4). Operating speed will be restricted through Columbia, but when combined with a station stop, it is not as damaging as it would otherwise appear to be.

Capacity Considerations

Satisfying capacity needs would be a component of any improvement program. Capacity analyses were not performed in the course of conducting this study, however, but it is possible to make reasonable assumptions about needs.

Central Route – Capacity analyses were conducted for the Central Route in 1997[5]. The analysis was conducted assuming base operations consisted of the current daily passenger train with local freight service over the entire route plus 6 coal trains (3 loaded and 3 empty) between Columbia and Savannah. Six intermodal trains (three in each direction) were shifted to the "S" line from the "A" line[6], as well as two passenger trains. The passenger trains were shifted to take advantage of the high-speed line (110 mph where possible), and the intermodal trains to create additional capacity on the "A" line. Four high-speed trains were added to the "S" line north of Raleigh traveling between New York and Charlotte. The analysis concluded that long sidings (over 1.0 miles long) should be spaced 15-20 miles apart if the "S" line was to carry additional trains south of Raleigh.

Thus, four-mile-long sidings were added where needed (no more than 15 miles or so apart) for purposes of this study. Existing sidings were extended where suitable and new ones created where not. Grade crossings and major bridges were avoided, or exposure at least minimized, in selecting siding locations.

Upstate Route – Capacity analyses have yet to be performed on the Upstate Route. Based on prior ridership estimates,[7] however, between four and six round trips (8 to 12 trains) would operate over the route segment. With existing freight traffic and an additional eight to twelve trains, capacity problems could result in the future. A logical plan would consider replacement of the second main track where it is missing, especially in areas where local trains tie up the main switching industries. For purposes of this study, a second main track was added to connect the double-track sections running through Spartanburg and Greenville (11 miles), one 4-mile addition to the south end, and two second track sections (totaling 10 miles) were added to the north end of the route to reduce the longest single-track sections to a level found on the south end, i.e., 4 to 5 miles. In reality, the amount of second track will depend on a detailed capacity analysis.

[5] *Piedmont High Speed Corridor Line Capacity Analysis Between Richmond and Savannah via CSX A and S Lines*, Wilbur Smith Associates, April 24, 1997.
[6] The CSXT main line through Florence.
[7] *Southeast High Speed Rail Market and Demand Study*, August 1997, prepared by KPMG Peat Marwick, Parsons Brinkerhoff Quade and Douglas, and Daniel Consultants.

Improvement Locations

Exhibits 2-5 and 2-6 depict the location and type of track improvements by route segment, Central and Upstate, respectively. As stated earlier, the capacity improvements are not the result of capacity studies, but rather attempts to estimate needs for the purpose of inclusion in this plan.

Chapter 3
GRADE CROSSINGS

While rail line improvements are included in the corridor planning process, the real focus of Section 1103 (c) of TEA-21 is at-grade rail-highway crossings and associated hazard elimination. The crossings on the two routes were subjected to examination and analysis, and recommendations for improvement are made for each.

Existing Crossings

Secondary data on each crossing was obtained from SCDOT files and the railroads. The data obtained identifies the roadway and location, (railroad milepost and county), pavement type and number of lanes, warning devices, and highway average daily traffic (ADT). With this data in hand, each crossing was visited in the field and checked for type of protection, use, sight distance, general condition, proximity to other crossings, geometry and potential for closure. The crossings were photographed and the field data recorded including supplemental information such as whether or not the crossing was "humped."[1] Relational sketches were made in some locations as appropriate to provide additional data where crossings were in close proximately to each other and/or where roadways parallel to the railroad might impact the subject crossings.

Crossing Numbers - The results of the identification and inspection process are summarized in Exhibits 3-1 and 3-2. Exhibit 3-1 reveals the number of at-grade crossings on each designated route. It also classifies the number of public and private crossings, with each route having approximately 20 private crossings per 100 public crossings. The density of crossings on the Central Route is slightly higher than the Upstate Route at 1.15 per mile versus 1.02, respectively.

[1] Crossing surface higher than roadway approaches, and high enough that vehicles might become stuck.

Exhibit 3-1
EXISTING AT-GRADE RAIL-HIGHWAY CROSSINGS

ROUTE	NUMBER OF CROSSINGS PUBLIC (PRIVATE)	AVERAGE CROSSINGS PER MILE
Central (CSXT)	195 (41)	1.15
Upstate (NS)	99 (20)	1.02

Public (Private)

In addition to at-grade crossings, there are 116 grade separations on the two routes—31 on the Central Route, concentrated on the north end, and 85 on the Upstate Route. The averages per mile are 0.15 and 0.70, respectively. The higher ratio on the Upstate Route is reflective of its more urbanized environment.

Warning Devices – The number of warning devices by type for each route is the subject of Exhibit 3-2. The exhibit reveals that active warning devices (flashing lights, gates) out number passive devices (cross bucks, stop signs) on each route, 124 to 112 (53 percent) on the Central Route, and by a large margin, 87 to 32 (73 percent), on the Upstate Route. There are, however, six private crossings with no warning devices.

Exhibit 3-2
EXISTING WARNING DEVICES

Route	Active		Passive		
	Lights	Lights & Gates	Crossbucks Only	Crossbucks with STOP Signs	No Devices
Central (CSXT)	9 (0)	114 (1)	31 (38)	41 (2)	0 (0)
Upstate (NS)	0 (0)	85 (2)	9 (12)	5 (0)	0 (6)

Public (Private)

Crossing Clusters – There are several locations on both routes where multiple crossings exist in close proximity to each other. These locations usually pose the greatest problems, but at the same time, they offer the greatest opportunity for closures.

On the Central Route these locations are: Cheraw, 9 crossings; Northeast Columbia, 7; Columbia College area in north Columbia, 7, Denmark, 7; Fairfax, 11; and Estill, 6. On the Upstate Route, the locations are: Blacksburg, 6 crossings; Gaffney, 13; Cowpens, 4; Greer, 6;

Taylors, 5; Rutherford Road area in Greenville (SC 291 – US 29), 6; and Easley, 4 roadways combined with 3 pedestrian crossings (not included in any of the exhibits).

Approach - The treatment of grade crossings was multi-pronged. Rather than examining each crossing on an individual basis, a corridor-wide approach was adopted to address crossings and determine the potential for closures. This process views crossings in relation to other crossings and connecting roadways so that functional interrelationships, both existing and potential, can be developed.

The work effort recognized the FRA guidelines for operations between 79 and 110 mph of eliminating not less than 25 percent of the crossings, with 50 percent as the target. Through roadways such as US, SC, and county routes, or major arterials were first separated from local streets and access roadways. Crossings were also examined for redundancy and existing or easily constructed access to other crossings. Justification for closure should be made on both safety and redundancy grounds although according to the FRA, national experience has shown that the most likely candidates are derived from those with good alternate routes. Considerable weight is given to public convenience and necessity in crossing closure decisions, and public convenience is measured in very short time intervals from the public's perspective. It is also important that the alternate crossing has adequate capacity to handle the added traffic, and that it is a safer crossing.

Desirable improvements to the remaining crossings (non-closures) were then addressed considering factors which assessed not only individual characteristics, but also changes in use as related to the closing of other crossings, or other modifications. Special attention was paid to private and public crossings with high accident rates, poor sight distance, located in curves or with bad crossing angles, with roadway intersections in close proximity, located in the vicinity of proposed speed-enhancing improvements, and other problem locations.

Although grade separations are not required (FRA guidelines) for the contemplated operating speeds, several candidates were identified. Separation candidates consisted of those with high vehicular volumes, emergency vehicle use, and located such that physical separations were possible.

While recommendations for both crossing improvements and closures, are made in this report, in the end, implementation will require negotiation with the parties involved, both public and private.

Crossing Improvements

Recommended improvements were developed for each crossing. Each improvement has elements that fall into one or more of the categories listed and described below. The first several approaches are aimed at improving active warning devices. Although not specifically itemized, constant warning devices are included with all new and modified installations and would be installed elsewhere as needed.

Add Lights & Gates – The installation of active flashing light signals and gates to be lowered to block the roadway where only passive devices exist today.

Add Gates – The installation of gates at locations where only flashing light signals currently exist.

Lengthen Gates/Add Median Barrier – Where the length of gates in the "down position" does not adequately block the path of a vehicle from crossing the track(s), it was recommended the gates be lengthened (usually by 2 to 3 feet) and/or a median barrier be constructed to discourage the action. The gate lengthening applies principally to narrow two-lane roadways where the gate extension would block both lanes. For wider crossing surfaces, see quad gates discussed next. Median barriers can be added to the existing pavement surface and could consist of a concrete or plastic material and include reflective delineators. This is intended as a method of improving the existing active protection or combined with lights and gates for new installations.

Install Quad Gates – The installation of additional lights and gates to provide gated protection to all approaches to a crossing (both sides of the roadway and track). These installations are recommended at locations that have wide or multi-lane roadway crossings, with high volumes of vehicular traffic and the potential for pedestrian crossings.

Add STOP Signs – The installation of STOP signs at crossings where active devices are not present.[2]

Close Crossing – In the immediate plan, to close a crossing means to remove the physical crossing and the related warning device. Under the 6-year and the long-range plans, crossing closures are potential closures. There were numerous crossings where potential closures were identified that would be dependant upon alternate access being established, or a grade separation constructed, or in some cases, a reconstruction or realignment of the rail corridor.

Grade Separation – Replacement and/or elimination of a present at-grade crossing by constructing an overpass or underpass for the roadway. This action would also result in a closure of one or more at-grade crossings. All grade separations are contained in the long-range plan.

Reconstruct Crossing – This improvement would involve the redesign of the roadway and or its approaches to the crossing to provide better alignment across the tracks. The improvement would also include reconstructing adjacent intersections that may be confusing or unclear to motorists.

Eliminate/Improve "hump" Crossings – This would involve the reconstruction of the roadway approaches to make a crossing smoother and traversable at higher speed, as well as eliminate the potential for long-wheelbase vehicles to become hung up on the track(s), or alternatively, change the elevation of the track.

Install Traffic Signal – Investigate the need for STOP & GO roadway signal control to be able to better "clear" the crossing of vehicles during heavy traffic flow periods. This is most likely to occur at locations where the crossing is close to a roadway intersection. It is assumed that locations where existing STOP and GO traffic signals are in place that the "railroad preemption" feature is operational.

[2] Installation would be based on need according to the South Carolina Manual on Uniform Traffic Control Devices. In addition, while the SCDOT has jurisdiction over public crossings, it has no jurisdiction over private crossings.

Manual Gates – Suggested by the FRA as one treatment for private crossings, the gate should span the roadway and be closed and locked in its normal position.

Recommendations

The recommended improvements were tabulated by both route and county. The latter is the subject of the Appendix and the former is discussed below.

Central Route – As shown earlier, the Central Route does not have the level of active warning devices that exists on the Upstate Route, and will require a more concentrated effort to "catch up." Almost 400 individual improvements[3] are recommended as listed in Exhibit 3-3, 25 percent of them in active warning device categories. Also, it will require a more extensive long-range effort if it is developed to its full potential as discussed in Chapter 2.

Exhibit 3-3
CENTRAL ROUTE CROSSING IMPROVEMENT RECOMMENDATIONS

IMPROVEMENT	PLAN RECOMMENDATIONS			
	Immediate	Six-Year	Long-Range	Totals
Lengthen Gates/Add Median Barrier	--	96 (1)	--	96 (1)
Add Lights & Gates	2 (0)	7 (0)	50 (4)	59 (4)
Add Gates	2 (0)	6 (0)	--	8 (0)
Install Quad Gates	--	20 (0)	2 (0)	22 (0)
Add Stop Signs	26 (34)	--	--	26 (34)
Close Crossing	--	34 (11)	5 (2)	39 (3)
Grade Separation	--	--	21 (0)	21 (0)
Reconstruct Crossing	1 (0)	4 (0)	--	5 (0)
Eliminate "Hump" – Improve Approaches	--	28 (10)	--	28 (10)
Install Traffic Signal	--	9 (0)	1 (0)	10 (0)
Install Manual Gates	--	--	0 (32)	0 (32)

Note: Public (Private)

Closure recommendations total 39 public and 3 private. These modifications represent 20 percent and 7 percent of each respective total, below target goals. Future planning efforts should identify additional opportunities.

[3] The number of improvements out number the number of crossings as some crossings are subjected to multiple treatments, e.g., improve warning devices and approaches.

Upstate Route – The Upstate Route, due to the more urbanized nature of large portions of its territory, and the larger number of trains using the line, already has a good level of active warning devices. By the same token, however, these same characteristics will dictate even higher levels with the introduction of additional and faster passenger trains. Based on the analysis contained in Chapter 2, the passenger train speeds will not, however, increase to the level anticipated for the Central Corridor.

The over 200 crossing improvements recommended for the route are shown in Exhibit 3-4. Very few of them involve active protection. Thirty-eight public crossings are recommended for closure, and seven private crossings. The recommendations comprise 38 percent and 35 percent of each category, respectively.

Exhibit 3-4
UPSTATE ROUTE CROSSING IMPROVEMENT RECOMMENDATIONS

	PLAN RECOMMENDATIONS			
IMPROVEMENT	**Immediate**	**Six-Year**	**Long-Range**	**Totals**
Lengthen Gates/Add Median Barrier	--	61 (1)	--	61 (1)
Add Lights & Gates	2 (0)	--	6 (1)	8 (1)
Add Gates	--	--	--	0 (0)
Install Quad Gates	--	17 (0)	--	17 (0)
Add Stop Signs	10 (13)	--	--	10 (13)
Close Crossing	--	27 (7)	11 (0)	38 (7)
Grade Separation	--	--	12 (0)	12 (0)
Reconstruct Crossing	--	2 (0)	--	2 (0)
Eliminate “Hump” – Improve Grades	1 (0)	37 (2)	--	38 (2)
Install Traffic Signal	--	1(0)	9 (0)	10 (0)
Install Manual Gates	--	--	0 (9)	0 (9)

Public (Private)

Chapter 4
PLAN DEVELOPMENT

Three plans are developed for the South Carolina SEHSR Corridor segments. They follow the Federal Highway Administration guidelines for development of a grade crossing improvement program in concert with the development of high-speed rail passenger service.

Corridor Segmentation

Initially the two routes were divided into three segments each as shown in Exhibit 4-1.

Exhibit 4-1
CORRIDOR SEGMENTATION

SEGMENT	LIMITS
Central Route	NC State line to Columbia Urban Area
	Columbia Urban Area
	Columbia Urban Area to GA State Line
Upstate Route	NC/SC State line to Spartanburg County Line
	Spartanburg and Greenville Counties
	Greenville County line to GA State Line

The purpose of the approach was to divide the routes into similar rural and urban sections. The concept for urban areas was expected to operate with reduced running speeds as is the practice in Europe, or bypasses would be constructed to maintain speed. In reality, the Central Route possesses different characteristics by segment as outlined. The Upstate Route, however, is more or less uniform throughout its traverse of South Carolina.

Plan Elements

Federal Highway Administration Guidelines for preparation of plans under Section 1103(c) of TEA-21, Railway-Highway Crossing Hazard Elimination in High Speed Rail Corridors, call for development of three plans which comprise three phases of the comprehensive plan. There is a long-range element, a six-year element, and an immediate element.

Long-Range Plan – This element can be conceptual and strategic and should cover a time period of 15-20 years. It should address rail alignment and equipment as well as at-grade crossings.

Six-Year Plan – This plan was to address projects for the six years of TEA-21. However, as there are only two years currently left for TEA-21, the six-year element for this study covers the time period but becomes basically a short-range plan. Crossings considered to be marginally safe should be addressed in this period.

Immediate Plan – This plan should be developed from a prioritized six-year plan. It should contain site-specific projects with cost estimates for which funding will be requested.

South Carolina Recommendations

The long-range objective of the four-state SEHSR coalition is to provide 110-mph rail passenger service along the designated corridors. South Carolina, as a member of the coalition, has the same objective. Improvements to meet these objectives over time fall into three categories – track, equipment and crossings. The plans developed in this study and discussed below are going to be subject to an evolving process as the implementation process is initiated and the work effort becomes more detailed.

Track – At the onset of this planning effort, the intent was to use existing rail lines in the designated corridors. These rail lines have been described in earlier sections of this report. The NS line, the Upstate Route, a heavily used freight route with alignment characteristics not conducive to high-speed operations, will require the greatest effort to meet SEHSR goals. In fact, a new alignment for all or large segments of the route will have to be considered long range if the top speed goal is to be met. Based on preliminary evaluations conducted as part of this effort, land development and population patterns in the area will make this a difficult task.

The Central Route is a more lightly used line and one which has promise for higher speed operations. While some major realignments are necessary north of Columbia, target speeds can be obtained south of Columbia with less drastic measures. Land development and population along the northern portion of the route are conducive at the present for the necessary realignments.

The following steps would comprise track-related elements for long-range development of high-speed service over the next 6 years.

Both Routes

1. Continue coordination with other coalition states to develop and progress a unified plan.
2. Establish contacts for project progression and technical matters with both CSXT and NS.
3. Proceed with the more easily accomplished speed improvements, e.g., turnout replacements, removal of municipal restrictions, increases in curve superelevation, etc. These improvements will provide immediate benefits for existing rail passenger service over both routes upon implementation.

Upstate Route

1. Conduct operating simulations on the existing Upstate Route for purposes of determining possible operating speeds and capacity under existing and future scenarios for both freight and passenger service.
2. Evaluate the potential to create a new alignment in the Upstate and proceed with engineering and environmental processes given favorable results.

Central Route

1. Advance the engineering and environmental evaluation of segment realignments suggested for the Central Route in this study.
2. Begin rail replacement with appropriate timbering and surfacing north of Columbia.

<u>Equipment</u> – The use of existing alignments virtually dictates adoption of tilt-train technology. Tilting equipment permits the increased operating speeds through curves immediately without realignment and minimizes realignment needs. Speed increases of up to 30 percent through curves on the average are possible. In particular, the state should:

1. Follow development of tilt equipment for use in the U.S. so that it will be in a position to make informed decisions when equipment needs are to be met.
2. Promote the FRA's development of a non-electric locomotive capable of sustaining target operating speeds.
3. Develop the necessary agreements for joint acquisition and operation with the other coalition states.

<u>Crossings</u> – The long-range plan is designed to meet corridor goals of at-grade crossing eliminations through closures and separations where appropriate. Improvements in warning devices are designated at remaining at-grade crossings. A summary of the effort for the three planning stages by route was the subject of Exhibits 3-3 and 3-4. A summary by county is contained in Appendix A.

As community consent will be needed to effect the at-grade crossing closures, it would be advantageous to begin immediately to establish working groups to address crossings at the local level. Such an effort has the potential to provide benefits for both the public and the railroads regardless of the ultimate development of the high-speed effort.

Chapter 5
COST ESTIMATES

Costs were estimated for rail line improvements -- rail infrastructure and grade crossings -- discussed in preceding chapters. The estimates are intended to provide a budget for immediate and six-year plans, and an order-of-magnitude assessment of long-range funding needs. Equipment or rolling stock costs are not included as these costs would be shared with other participants. The same holds true for equipment maintenance and servicing facilities.

Level of Accuracy

Capital cost estimates are typically prepared in a series of stages, each based on a more detailed level of design analysis and, hence, each more reliable than the previous estimate. These progressive stages can be defined as:

?? **Reconnaissance** – Based on brief field investigation and review of existing mapping;

?? **Conceptual or Planning** – Design configuration developed from initial engineering analysis, existing large-scale mapping and limited site verification, without detailed surveys;

?? **Preliminary Engineering –** Basic dimensioning and design features established based on project-specific surveys and mapping; and

?? **Final Design** – Complete design, ready for construction. This cost estimate is usually referred to as an Engineer's Estimate.

To provide as reliable an estimate as possible at each of these stages, a contingency allowance is usually added to the basic estimate, decreasing in magnitude as design details improve. The normal contingency rate is 40 – 50 percent at the reconnaissance level to 10 - 15 percent at the Final Design level.

The capital cost estimates for this study are based on an engineering analysis which could probably be characterized as lying between the Reconnaissance and Conceptual or

Planning level. Capital costs were developed from estimated quantities of work and unit prices derived specifically for this study.

Unit Costs

Unit costs were developed for track and signal work. Signal work is comprised of train control and at-grade rail-highway warning devices. The unit costs are shown in Exhibit 5-1.

Not included in the signal costs for the train control system for over 80-mph operation, however, is the cost to equip locomotives with the necessary devices. Equipment needs apply to freight locomotives operating over the route as well as passenger motive power. Costs would range between $25,000 and $100,000 per unit depending on the actual system adopted. The railroad would have to either equip all of its power or assign certain units to operate over the high-speed route. The latter requires locomotive changes, increasing costs and restricting operating flexibility.

Route Estimates

The capital cost estimates were prepared for each route based on the improvements discussed in the previous two chapters.

Upstate Route – The capital costs associated with the Upstate Route are small, comparatively speaking, as the goal for this route in terms of operating speed is to increase the average, not the maximum. This goal will be met principally through the use of tilting passenger equipment.

The estimate of capital costs is contained in Exhibit 5-2. As evident from examination of the exhibit, the largest share of the $145-million estimate is attributable to grade crossing improvements, namely grade separations. As expressed earlier, track improvements relate largely to added capacity and consist of replacement of part of the former second main track.

Central Route – Unlike the Upstate Route, the largest portion (almost 70 percent) of the $742-million cost estimate (see Exhibit 5-3) is dedicated to speed improvements. Capacity and

Exhibit 5-1
ESTIMATED UNIT COSTS

Category	Item	Unit	Estimated Cost
Track	High Speed Turnouts w/c.p.	ea.	$500,000.00
	Rail Replacement, new	mi.	335,000.00
	Concrete Tie Installation	TF	45.00
	Improve Class 4 Track to Class 6	TF	16.00
	Construct New Track	mi.	640,000.00
	Minor Realignment	mi.	1,300,000.00
	Major Realignment	mi.	2,000,000.00
	New Roadbed Adjacent to Existing	mi.	670,560.00
	Realign Track(1)	TF	17.00
	Surface Track w/ballast	TF	6.40
Signals	New Train Control System(2)	mi.	$450,000.00
	Electric Locks	ea.	$67,000.00
	Warning Device with FL & G(3)	per crossing	165,000.00
	Upgrade FL with Gates	per crossing	165,000.00(4)
	Lengthen Gate Arms	per crossing	2,500.00
	Improve 2 Gates to Quad Gates	per crossing	165,000.00
	Add Stop Signs	per crossing	500.00
	Crossing Closure	per crossing	25,000.00
	Grade Separation	per crossing	5,000,000.00
	Reconstruct Crossing	per crossing	11,000.00
	Improve “Hump” Crossings	per crossing	40,000.00
	Install Traffic Signal	per crossing	45,000.00
	Install Manual Gates	per crossing	5,000.00
	Relocate Crossing Active Device	per crossing	10,000.00
Other	Utility and Culvert Adjustments	mi.	$160,000.00
	Fiber Optic Relocation	mi.	150,000.00
	Acquire Right-of-Way, Rural	Ac.	15,000.00
	Acquire Right-of-Way, Urban	Ac.	60,000.00
	Construct Grade Crossing	TF	300.00
	Railroad Bridge	TF	3,000.00
	Station and Parking	ea.	1,250,000.00

(1) On existing roadbed.
(2) With provision for cab signals or automatic train stop.
(3) FL & G – Flashing lights and gates.
(4) Based on SCDOT experience

ea – each
mi – mile
TF – Track Foot
Ac. – Acre

Source: Wilbur Smith Associates
ABC-NACO

Exhibit 5-2
COST ESTIMATE
Upstate Route

SPEED IMPROVEMENTS (Maximum 79 MPH)

ITEM	COST (Millions)
1. Convert Equilateral TOs	$2.5
2. Realign Curves	2.2
3. Increase Superelevation	1.0
4. Electric Locks	0.5
Subtotal	$6.2
Engr & Cont	2.5
Total	$8.7
CAPACITY IMPROVEMENTS	
1. Second Main Track	$17.1
2. Connections & Crossovers	3.1
3. Utility Adjustments	3.2
4. Fiber Optic Cable Relocations	3.0
Subtotal	$26.4
Engr & Cont	10.6
Total	$37.0
GRADE CROSSING IMPROVEMENTS	
1. Immediate	$0.4
2. Six-Year	5.4
3. Long-Range	61.9
Subtotal	$67.7
Engr & Cont	27.1
Total	$94.8
OTHER	
Stations and Parking(1) (including Engr & Cont)	4.4
Route Total	$144.9

(1) One-half of costs for five unspecified locations.

Exhibit 5-3
COST ESTIMATE
Central Route

SPEED IMPROVEMENTS (Maximum 110 MPH)

ITEM	COST (Millions)
1. Replace Rail North End	$31.6
2. Class 4 track to Class 6	3.1
3. Concrete Tie Installation	46.7
4. Alignment Changes (minor and major)	134.8
5. Train Control System (cab signals)	88.4
6. Utility Adjustments	10.5
7. Fiber Optic Cable Relocation	9.9
8. Right-of-Way	26.5
Subtotal	$351.5
Engr & Cont	140.6
Total	$492.1
CAPACITY IMPROVEMENTS	
1. Construct Sidings	$37.6
2. Utility Adjustments	7.0
3. Relocate Fiber Optic Cable	6.5
Subtotal	$51.1
Engr & Cont	20.4
Total	$71.5
GRADE CROSSING IMPROVEMENTS	
1. Immediate	$0.7
2. Six-Year	8.8
3. Long-Range	114.6
Subtotal	$124.1
Engr & Cont	49.6
Total	$173.7
OTHER	
Stations and Parking[1] (including Engr & Cont)	4.4
Route Total	$741.7

(1) One-half of costs for five unspecified locations.

grade crossing improvements comprise 9.7 and 23.4 percent, respectively, of the total estimated cost.

Plan Funding Needs

Exhibits 5-1 and 5-2 depict total funding needs. Needs by plan component, i.e., immediate, six-year, and long-range, however, are not shown in the exhibits.

The breakdown of the grade crossing costs over time has already been discussed. Track-related capital improvements are mostly long-range, but some intermediate efforts are desirable, and in some cases, such as planning and engineering, are necessary to progress the long-range plan.

Continuation of this planning effort with train simulations and commencement of more detailed evaluations of potential realignments would fall into the immediate category. The engineering and environmental effort would continue into the six-year effort, with perhaps some right-of-way acquisition if engineering and environmental efforts progress far enough. The more easily implemented improvements such as increases in superelevation of existing curves not to be realigned, minor realignments, replacement of equilateral turnouts on the Upstate Route, rail replacement on the Central Route, and removal of municipal restrictions in combination with the grade crossing improvement program would also be implemented within this period. As noted previously, these improvements will provide immediate benefits for existing passenger service.

The remainder of the improvements would fall into the long-range category. Priorities for implementation would constitute part of the continuing planning effort. Funding needs to adhere to this schedule over time are the subject of Exhibit 5-4.

Exhibit 5-4
PLAN COMPONENT FUNDING NEEDS

Component	Estimated Costs
Immediate	$1.2
Six-Year	147.7
Long-Range	737.7
TOTAL	$886.6

Chapter 2

ROUTE SEGMENT IMPROVEMENTS

The routes through South Carolina comprising the SEHSR Corridor were examined and their potential to meet Corridor goals determined. Needed improvements were identified and quantified.

ROUTE SEGMENTS

The designated corridor routes in South Carolina are single-line rather than multiple line corridors in that a single rail line is located within each. For the purposes of this study, the two legs of the SEHSR Corridor are designated as the Central and Upstate Routes. The Central Route is home to CSXT's "S" Line, the main line of the former Seaboard Air Line Railway. The Upstate Route is home to the Washington, DC-Atlanta, GA main line of NS.

Central Route

The "S" line is 205.3 miles long from the North Carolina – South Carolina state line to the Georgia border at the Savannah River. The route passes through Cheraw, Patrick, McBee, Bethune and Camden before reaching Columbia and heading almost due south through Swansea, North, Norway, Denmark, and Fairfax en-route to Savannah (see Exhibit 2-1).

Line Use – In addition to the passenger train which runs in each direction daily, Amtrak's *Silver Star,* the line functions as a secondary main line for CSXT freight operations. Freight operations average 3-5 trains per day north of Fairfax and 12-13 south of Fairfax with the addition of trains to and from a connecting CSXT line.

Train Control – Operations on the line are governed by a traffic control signal system (TCS) with block signals authorizing train movement.

Track Characteristics – The line is basically single-track with dispatcher controlled sidings located 15 to 35 miles apart. The track is constructed of steel rail with mixed hardwoods

on crushed stone ballast. Rail weights are as follows, and approximately follow the order shown from north to south.

- ?? 28.9 miles of 112-lb.welded rail
- ?? 31.2 miles of 115-lb. jointed rail
- ?? 84.7 miles of 115-lb. welded rail
- ?? 31.0 miles of 131-lb. welded rail
- ?? 29.5 miles of 132-lb. welded rail

Operating Speed – North of Columbia, the maximum permissible speed for passenger trains is 60 mph. It is believed the speed is restricted due to the lighter rail weights and the non-welded segment. It is further restricted, principally to 50-55 mph, in many locations and 40-45 mph in some locations due to curvature. Two to four degree curves are common.

The operating speed is restricted to 30-40 mph through Columbia, approximately four miles.

South of Columbia, the maximum permissible speed for passenger trains increases to 79 mph. Curvature again restricts operating speeds between Columbia and Norway (40 miles), but south of Norway there are only eight curves, and the few restrictions that do exist are not a result of curvature, but rather municipal ordinances

Upstate Route

The NS line in South Carolina is 122 miles long from the North Carolina to the Georgia border. It traverses the industrialized Piedmont section of the state running through the communities of Blacksburg, Gaffney, Spartanburg, Greer, Greenville, Easley, and Clemson as shown in Exhibit 2-1.

Line Use – The route is a very heavily used segment of NS's mainline line system. Eighteen to twenty freight trains per day are joined by Amtrak's daily *Crescent*.

Train Control – The NS line is traffic control (TC) and remote control territory meaning a dispatcher controls routing on the line which is alternating double and single track. The former double-tracked line was reconfigured with the installation of TC and the second track removed every other 10 miles or so several decades ago.

Track Characteristics - The trackage through South Carolina currently is comprised of 64 miles of double track and 58 miles of single track. The entire route is laid with 132-lb. welded rail.

Operating Speeds – The maximum permissible speed for passenger trains over the line is 79 mph. Very little of the line is operated at this speed, however, due to the presence of multiple curves. In fact, only 6.6 miles of the route in South Carolina can be operated at the maximum permissible speed. Curvature is not the only factor limiting speed, however, as there are also restrictions at grade crossings, one stretch without electric locks on mainline turnouts, and mainline equilateral turnouts at the single track – double track junctions.

Compatibility of Existing and Proposed Corridor Operations

Rail freight and rail passenger services have very different operational characteristics, needs, and priorities. As long as the same railroad and decision-makers are involved, as long as traffic densities are not too great, and as long as train speeds are within a reasonable range, these interface issues can usually be handled. However, as density builds, as the number of entities (with different priorities) involved in decisions increases, and especially when higher speed trains are introduced creating a wider speed gap with existing operations, the interaction between the two types of railroad operation becomes more complicated and, in some corridors, prohibitive.

The interaction problems range from curve elevation (superelevation) and overhead clearance issues (catenary); to operational priorities and capacity problems; and, finally to infringements and tradeoffs from a service standpoint. If enhanced rail passenger services are to coexist with rail freight services, and especially if they are to use the same track, tradeoffs will have to be developed and considered. Precedents may well have already been set in other states, e.g., the terms of the renewed NS lease of the North Carolina Railroad which limits passenger train operations to 90 mph on the same track as NS freight operations, and calls for a separate track for higher speeds.

Regulations and Guidelines – Exhibit 2-2 (following page) depicts federal regulations and guidelines governing permissible passenger train operating speeds. Governing factors consist of both track condition as measured by Federal Railroad Administration Track Safety Classifications, train control (signal) systems, and rail-highway crossing characteristics. Corridor plans were developed around those regulations and guidelines for the 79 – 110 mph category.

Physical Conflicts – One of the physical problems relates to superelevation of curves. The high-speed passenger service will require greater elevation in curves than freight trains need, even considering authorized "unbalanced" elevation. Another physical problem relates to the level of maintenance (FRA track class) required for high-speed trains and the related maintenance problems created by "tonnage" freight trains. Similarly there will be overhead clearance issues if the passenger system were electrified, etc. The differential in operating speeds with high-speed passenger trains also impacts wayside signals as well as grade crossing warning devices and related circuitry. Problems were identified, defined and considered in formulating the approach to development of the SEHSR Corridor in South Carolina.

CORRIDOR IMPROVEMENTS

The two routes were assessed using railroad track charts, timetable data, USGS quadrangle maps and field reconnaissance, both aerial and on-the-ground.

Speed Limitations

The initial effort used track chart and timetable data to identify existing speed limits. Maximum permissible speeds are governed by safety regulations (see Exhibit 2-2) pertaining to the type of train control system and track class. Both routes have a maximum permissible speed of 79 mph which is typical of most rail lines over which passenger service is operated. There are only a few lines in the United States with higher speed limits, the most notable of which is the Northeast Corridor.

Exhibit 2-2
REGULATIONS AND GUIDELINES GOVERNING PERMISSIBLE OPERATING SPEEDS

Speed Range	Characteristics (Examples)	Train Control	Other Right-of-Way
AConventional@ up to 79 mph	Typical Amtrak service provided on most of the national route system. FRA Class 4 track.	Automatic block signals, centralized traffic control.	Active and passive at-grade rail-highway crossing warning devices.
AImproved Conventional High Speed@ 79-110 mph	Requires cab signals, and may require train stop or train control, under current regulations. Existing service: Amtrak service on several railroads in cab signal territory. FRA Class 5 and Class 6 track.	Continuous cab signals which provide a display of train-control signals in the locomotive cab, automatic train stop or train control systems for automatically controlling train speed and stopping trains.	Minimize number of at-grade crossings and increase number of active warning devices where possible. Detectors for failed bearings, slides, etc.
AAdvanced High Speed@ 110-125 mph	Not permitted under existing FRA Track Safety Standards, except by waiver. Existing service: Metroliner service on the Northeast Corridor between Washington and New York. Maximum speeds for diesel-electric and turbo trains.	Continuous cab signals with automatic train control and positive stop.	At-grade crossings not permitted unless research demonstrates effectiveness of barrier/detector. Plus explore sensors for bridges, fencing where warranted; limit freight traffic to off hours where possible.
AVery High Speed@ 125-150 mph	Speed range of all-electric trains and effective use of tilt equipment.	Plus protection for temporary slow orders.	At-grade rail-highway crossings not permitted. Plus comprehensive incursion plan; freight limited to off hours.
"Super High Speed" 150-250 mph	Only the French TGV (to 200 mph), the German ICE (to 156 mph), and the Japanese Shinkansen (to 168 mph) currently operate revenue service in this range.	Plus protection for temporary slow orders.	At-grade rail-highway crossings not permitted. Plus dedicated right-of-way (no freight or other traffic).
AUltra High Speed" >250 mph	Maglev and third generation steel-wheel-on-steel-rail equipment.	Plus protection for temporary slow orders.	At-grade rail-highway crossings not permitted. Plus dedicated right-of-way (no freight or other traffic).

Source: Federal Railroad Administration

Restrictions – Typically railroad speed restrictions[1] fall into these general categories:

?? Governmental ordinances;

?? Turnouts/Crossovers;

?? Curvature; and

?? Others (yard limits, at-grade crossings of other railroads, bridges, and tangent track between restricted curves).

While restrictions in virtually all of the categories exist on the designated routes, the most prevalent is due to curvature, and for that reason, it is discussed in some detail in the following paragraphs.

Curvature – Curves present both safety and passenger comfort issues. The speed at which a passenger train may negotiate a curve without causing discomfort to passengers or climbing off the track is determined by two things – 1) the degree of curvature (the measure of the sharpness of the curve), and 2) the amount of superelevation (the measure of how much the outer rail is raised or "banked" above the inner rail to compensate for the lateral force of gravity encountered in a curve).

Since trains are longer, heavier, and have higher centers of gravity than say, automobiles, railroad curves are usually longer and flatter than highway curves, but the principle is the same. As with other kinds of moving vehicles, the safe speed going around a curve – that is, a speed less than the overturning speed – is higher than the limits imposed by comfort. So, one of the principal reasons for superelevating curves, in addition to preventing overturning of vehicles, is to ensure passenger comfort. If it were not for the impact of lateral "G" forces[2] on the human body, vehicles could go around curves at speeds much higher than they do. Eventually, of course, a train will turn over or climb off the track if the speed is high enough and the curve sharp enough. So, superelevating a curve both increases the maximum safe speed and provides rider comfort.

[1] A restriction being an operating speed less than the maximum permissible for a line segment.
[2] Force exerted by gravity on a body at rest and used to indicate the force to which a body is subjected when accelerated.

There are two elements of superelevation which are used in determining permissible train speeds – 1) actual and 2) unbalanced. In American railroad practice, actual physical superelevation does not exceed six inches (and typically lower, 4 to 5 inches, on freight railroads). Greater superelevation than this produces higher maintenance costs, and interferes with the economical operation of freight trains and thus, with freight trains being the predominate user of U.S. main tracks, the actual superelevation is typically less than the maximum. This practice permits freight trains to traverse curves at equilibrium speeds.[3]

Conventional passenger trains can generally operate around curves at speeds in excess of equilibrium speeds, without impairing safety or comfort. For conventional passenger trains operating in the United States, the degree to which trains can exceed the equilibrium speed is the equivalent of three inches of "unbalance," or non-existent superelevation. That is, on a typical main line railroad curve, the superelevation required for "equilibrium" at the target operating speed is three inches more than the actual physical superelevation. "Unbalance" is also sometimes called "cant deficiency," an English railroad engineering term that describes what is missing; namely, the amount of additional superelevation of the outer rail that would be needed to restore equilibrium. Tilt equipment, however, provides a comfortable ride at greater imbalance, and thus a greater "cant deficiency" and a corresponding higher speed is permitted.

Speed Enhancement

Once the speed restrictions on the study routes had been identified, means to eliminate or mitigate them were considered. A phased program to address potential solutions in ascending order of complexity was derived.

Enhancement Cases – In all, four levels of speed enhancement were developed. A fifth case used in the analysis, the base case or existing conditions, served as a basis for comparison for the enhancement cases. The cases are defined in Exhibit 2-3. In all cases, appropriate train control system modifications are also to be made to permit the possible speeds.

[3] Equilibrium speed is the speed through a curve at which the superelevation is exactly enough that the centrifugal force pushing out is balanced against the gravitational force pulling in. In other words, the weight-to-force distribution is equal on both rails and, thus, on ties and ballast, i.e., no "creeping" or loss of gage.

Exhibit 2-3
ENHANCEMENT LEVELS

CASE	DESCRIPTION
1	Base
2	Remove city ordinances, add electric locks, etc.
3	Case 2 with 6 inches of cant deficiency
4	Case 3 with curve realignments
5	Case 4 with route changes

The first level of enhancement (Case 2) is comprised of items more easily accomplished then intensive capital projects with long lead times for engineering and permitting. Included in this category are replacement of equilateral turnouts with right/left-hand turnouts (permitting a faster speed on the non-diverging side), installation of electric locks on turnouts that do not have them, and lifting municipal restrictions. The latter may well be accompanied by grade crossing warning device improvements.

The next level (Case 3) would result from the use of tilt train equipment on the routes. Needless to say, significant levels of investment would begin here.

The last two cases, 4 and 5, involve improvements in the alignment of the existing rail lines. In Case 4,only curves are realigned to reduce the degree of curvature permitting an increase in operating speeds. In Case 5, relocations of line segments were examined in several locations where multiple curves could be lightened or eliminated at one time. Proposed alignment changes were planned using USGS quadrangle mapping, and available aerial photography. The potential improvements were field checked by air for bcational feasibility followed in some cases by ground reconnaissance.

Enhancement Case Results –The contemplated improvements were put into place for each case and the results measured in train operating times (theoretical running time) given the new permissible speeds and the applicable distances to which they apply. The measurement was made by computing a time to traverse each route segment by dividing the segment length by the permissible speed. The results are the subject of Exhibit 2-4. No train simulations[4] were performed, therefore, acceleration and deceleration impacts are not accounted for in the theoretical running time. These impacts vary according to the number of times speed has to be changed and the severity of the change, but would tend to lower average speed and thus increase running time.

Exhibit 2-4
ALTERNATE IMPROVEMENT PLAN RESULTS

		Case				
Route	**Item**	**1**	**2**	**3**	**4**	**5**
Central (CSXT) (206 mi)	TRT (min)[1]	197.0	195.3	151.4	144.2	128.8
	AS (mph)[2]	62.7	63.2	81.5	85.6	95.8
	IMP (min)[3]		1.7	43.9	7.2	15.4
Upstate (NS) (122 mi)	TRT (min)[1]	127.4	125.2	98.2	92.1	87.7
	AS (mph)[2]	57.4	58.4	74.5	79.4	83.3
	IMP (min)[3]		1.9	27.3	6.1	4.4

(1) Theoretical Running Time – Based on permissible speed per segment of each route.
(2) Average Speed – Length of line segment divided by permissible speed over which speed limit applies.
(3) Improvement – Incremental difference in theoretical running time from case to case.

As evident from review of the table, there is very little change in the running time between Case 1 and 2 as locations are limited and short distances are involved. Based on prior experience, however, removal of the restrictions in Case 2 are more productive than indicated when the time lost in reducing and resuming operating speeds at each location is considered.

Significant changes resulting from the use of tilting rolling stock are evident between Cases 2 and 3. A quick review of the remainder of the table reveals that this one action produces the biggest result of any of the improvement methods.

The curve realignments in Case 4 are not real productive, but here again would prove to produce better results once acceleration and deceleration are considered. The results show more potential for the Upstate Route than for the Central Route on a per-mile basis.

[4] A computer program which simulates the operation of a specified train consist (motive power and passenger cars) over a rail route with specified alignment and gradient characteristics at permissible speeds.

The route segment realignments in Case 5 appear to produce mixed results for the two routes. The effect has little impact on the Upstate Route but holds greater promise for the Central Route. In fact, on a per-mile basis, it is even more effective as most of the realignments are located on the north end of the segment.

Enhancement Implications – The results of the improvement scenarios imply that the use of tilt equipment holds the most promise for significant speed increases and corresponding running time decreases. Increases in either real or unbalanced track superelevation would enhance the option, both of which would have negotiated with the owning railroad and in the latter case, the FRA.

Minor curve realignments hold some promise on the Upstate Route while route segment realignments do not. Based on field and air reconnaissance, the proposed major route realignments would be difficult to implement anyway due to the level of development along the railroad for most of its route through the state. Thus, the most realistic approach to Upstate Corridor speed-related improvements appear to be the use of tilting rolling stock with selective curve realignments, the latter to be performed only where truly effective (see recommendations in Chapter 4).

The long segments of tangent track on the south end, and the potentially successful segment realignments on the north end, hold promise to meet the target speeds on the Central Route (see recommendations in Chapter 4). Operating speed will be restricted through Columbia, but when combined with a station stop, it is not as damaging as it would otherwise appear to be.

Capacity Considerations

Satisfying capacity needs would be a component of any improvement program. Capacity analyses were not performed in the course of conducting this study, however, but it is possible to make reasonable assumptions about needs.

Central Route – Capacity analyses were conducted for the Central Route in 1997[5]. The analysis was conducted assuming base operations consisted of the current daily passenger train with local freight service over the entire route plus 6 coal trains (3 loaded and 3 empty) between Columbia and Savannah. Six intermodal trains (three in each direction) were shifted to the "S" line from the "A" line[6], as well as two passenger trains. The passenger trains were shifted to take advantage of the high-speed line (110 mph where possible), and the intermodal trains to create additional capacity on the "A" line. Four high-speed trains were added to the "S" line north of Raleigh traveling between New York and Charlotte. The analysis concluded that long sidings (over 1.0 miles long) should be spaced 15-20 miles apart if the "S" line was to carry additional trains south of Raleigh.

Thus, four-mile-long sidings were added where needed (no more than 15 miles or so apart) for purposes of this study. Existing sidings were extended where suitable and new ones created where not. Grade crossings and major bridges were avoided, or exposure at least minimized, in selecting siding locations.

Upstate Route – Capacity analyses have yet to be performed on the Upstate Route. Based on prior ridership estimates,[7] however, between four and six round trips (8 to 12 trains) would operate over the route segment. With existing freight traffic and an additional eight to twelve trains, capacity problems could result in the future. A logical plan would consider replacement of the second main track where it is missing, especially in areas where local trains tie up the main switching industries. For purposes of this study, a second main track was added to connect the double-track sections running through Spartanburg and Greenville (11 miles), one 4-mile addition to the south end, and two second track sections (totaling 10 miles) were added to the north end of the route to reduce the longest single-track sections to a level found on the south end, i.e., 4 to 5 miles. In reality, the amount of second track will depend on a detailed capacity analysis.

[5] *Piedmont High Speed Corridor Line Capacity Analysis Between Richmond and Savannah via CSX A and S Lines*, Wilbur Smith Associates, April 24, 1997.
[6] The CSXT main line through Florence.
[7] *Southeast High Speed Rail Market and Demand Study*, August 1997, prepared by KPMG Peat Marwick, Parsons Brinkerhoff Quade and Douglas, and Daniel Consultants.

Improvement Locations

Exhibits 2-5 and 2-6 depict the location and type of track improvements by route segment, Central and Upstate, respectively. As stated earlier, the capacity improvements are not the result of capacity studies, but rather attempts to estimate needs for the purpose of inclusion in this plan.

Chapter 3
GRADE CROSSINGS

While rail line improvements are included in the corridor planning process, the real focus of Section 1103 (c) of TEA-21 is at-grade rail-highway crossings and associated hazard elimination. The crossings on the two routes were subjected to examination and analysis, and recommendations for improvement are made for each.

Existing Crossings

Secondary data on each crossing was obtained from SCDOT files and the railroads. The data obtained identifies the roadway and location, (railroad milepost and county), pavement type and number of lanes, warning devices, and highway average daily traffic (ADT). With this data in hand, each crossing was visited in the field and checked for type of protection, use, sight distance, general condition, proximity to other crossings, geometry and potential for closure. The crossings were photographed and the field data recorded including supplemental information such as whether or not the crossing was "humped."[1] Relational sketches were made in some locations as appropriate to provide additional data where crossings were in close proximately to each other and/or where roadways parallel to the railroad might impact the subject crossings.

Crossing Numbers - The results of the identification and inspection process are summarized in Exhibits 3-1 and 3-2. Exhibit 3-1 reveals the number of at-grade crossings on each designated route. It also classifies the number of public and private crossings, with each route having approximately 20 private crossings per 100 public crossings. The density of crossings on the Central Route is slightly higher than the Upstate Route at 1.15 per mile versus 1.02, respectively.

[1] Crossing surface higher than roadway approaches, and high enough that vehicles might become stuck.

Exhibit 3-1
EXISTING AT-GRADE RAIL-HIGHWAY CROSSINGS

ROUTE	NUMBER OF CROSSINGS PUBLIC (PRIVATE)	AVERAGE CROSSINGS PER MILE
Central (CSXT)	195 (41)	1.15
Upstate (NS)	99 (20)	1.02

Public (Private)

In addition to at-grade crossings, there are 116 grade separations on the two routes—31 on the Central Route, concentrated on the north end, and 85 on the Upstate Route. The averages per mile are 0.15 and 0.70, respectively. The higher ratio on the Upstate Route is reflective of its more urbanized environment.

Warning Devices – The number of warning devices by type for each route is the subject of Exhibit 3-2. The exhibit reveals that active warning devices (flashing lights, gates) out number passive devices (cross bucks, stop signs) on each route, 124 to 112 (53 percent) on the Central Route, and by a large margin, 87 to 32 (73 percent), on the Upstate Route. There are, however, six private crossings with no warning devices.

Exhibit 3-2
EXISTING WARNING DEVICES

Route	Active		Passive		
	Lights	Lights & Gates	Crossbucks Only	Crossbucks with STOP Signs	No Devices
Central (CSXT)	9 (0)	114 (1)	31 (38)	41 (2)	0 (0)
Upstate (NS)	0 (0)	85 (2)	9 (12)	5 (0)	0 (6)

Public (Private)

Crossing Clusters – There are several locations on both routes where multiple crossings exist in close proximity to each other. These locations usually pose the greatest problems, but at the same time, they offer the greatest opportunity for closures.

On the Central Route these locations are: Cheraw, 9 crossings; Northeast Columbia, 7; Columbia College area in north Columbia, 7, Denmark, 7; Fairfax, 11; and Estill, 6. On the Upstate Route, the locations are: Blacksburg, 6 crossings; Gaffney, 13; Cowpens, 4; Greer, 6;

Taylors, 5; Rutherford Road area in Greenville (SC 291 – US 29), 6; and Easley, 4 roadways combined with 3 pedestrian crossings (not included in any of the exhibits).

Approach - The treatment of grade crossings was multi-pronged. Rather than examining each crossing on an individual basis, a corridor-wide approach was adopted to address crossings and determine the potential for closures. This process views crossings in relation to other crossings and connecting roadways so that functional interrelationships, both existing and potential, can be developed.

The work effort recognized the FRA guidelines for operations between 79 and 110 mph of eliminating not less than 25 percent of the crossings, with 50 percent as the target. Through roadways such as US, SC, and county routes, or major arterials were first separated from local streets and access roadways. Crossings were also examined for redundancy and existing or easily constructed access to other crossings. Justification for closure should be made on both safety and redundancy grounds although according to the FRA, national experience has shown that the most likely candidates are derived from those with good alternate routes. Considerable weight is given to public convenience and necessity in crossing closure decisions, and public convenience is measured in very short time intervals from the public's perspective. It is also important that the alternate crossing has adequate capacity to handle the added traffic, and that it is a safer crossing.

Desirable improvements to the remaining crossings (non-closures) were then addressed considering factors which assessed not only individual characteristics, but also changes in use as related to the closing of other crossings, or other modifications. Special attention was paid to private and public crossings with high accident rates, poor sight distance, located in curves or with bad crossing angles, with roadway intersections in close proximity, located in the vicinity of proposed speed-enhancing improvements, and other problem locations.

Although grade separations are not required (FRA guidelines) for the contemplated operating speeds, several candidates were identified. Separation candidates consisted of those with high vehicular volumes, emergency vehicle use, and located such that physical separations were possible.

While recommendations for both crossing improvements and closures, are made in this report, in the end, implementation will require negotiation with the parties involved, both public and private.

Crossing Improvements

Recommended improvements were developed for each crossing. Each improvement has elements that fall into one or more of the categories listed and described below. The first several approaches are aimed at improving active warning devices. Although not specifically itemized, constant warning devices are included with all new and modified installations and would be installed elsewhere as needed.

Add Lights & Gates – The installation of active flashing light signals and gates to be lowered to block the roadway where only passive devices exist today.

Add Gates – The installation of gates at locations where only flashing light signals currently exist.

Lengthen Gates/Add Median Barrier – Where the length of gates in the "down position" does not adequately block the path of a vehicle from crossing the track(s), it was recommended the gates be lengthened (usually by 2 to 3 feet) and/or a median barrier be constructed to discourage the action. The gate lengthening applies principally to narrow two-lane roadways where the gate extension would block both lanes. For wider crossing surfaces, see quad gates discussed next. Median barriers can be added to the existing pavement surface and could consist of a concrete or plastic material and include reflective delineators. This is intended as a method of improving the existing active protection or combined with lights and gates for new installations.

Install Quad Gates – The installation of additional lights and gates to provide gated protection to all approaches to a crossing (both sides of the roadway and track). These installations are recommended at locations that have wide or multi-lane roadway crossings, with high volumes of vehicular traffic and the potential for pedestrian crossings.

Add STOP Signs – The installation of STOP signs at crossings where active devices are not present.[2]

Close Crossing – In the immediate plan, to close a crossing means to remove the physical crossing and the related warning device. Under the 6-year and the long-range plans, crossing closures are potential closures. There were numerous crossings where potential closures were identified that would be dependant upon alternate access being established, or a grade separation constructed, or in some cases, a reconstruction or realignment of the rail corridor.

Grade Separation – Replacement and/or elimination of a present at-grade crossing by constructing an overpass or underpass for the roadway. This action would also result in a closure of one or more at-grade crossings. All grade separations are contained in the long-range plan.

Reconstruct Crossing – This improvement would involve the redesign of the roadway and or its approaches to the crossing to provide better alignment across the tracks. The improvement would also include reconstructing adjacent intersections that may be confusing or unclear to motorists.

Eliminate/Improve "hump" Crossings – This would involve the reconstruction of the roadway approaches to make a crossing smoother and traversable at higher speed, as well as eliminate the potential for long-wheelbase vehicles to become hung up on the track(s), or alternatively, change the elevation of the track.

Install Traffic Signal – Investigate the need for STOP & GO roadway signal control to be able to better "clear" the crossing of vehicles during heavy traffic flow periods. This is most likely to occur at locations where the crossing is close to a roadway intersection. It is assumed that locations where existing STOP and GO traffic signals are in place that the "railroad preemption" feature is operational.

[2] Installation would be based on need according to the South Carolina Manual on Uniform Traffic Control Devices. In addition, while the SCDOT has jurisdiction over public crossings, it has no jurisdiction over private crossings.

Manual Gates – Suggested by the FRA as one treatment for private crossings, the gate should span the roadway and be closed and locked in its normal position.

Recommendations

The recommended improvements were tabulated by both route and county. The latter is the subject of the Appendix and the former is discussed below.

Central Route – As shown earlier, the Central Route does not have the level of active warning devices that exists on the Upstate Route, and will require a more concentrated effort to "catch up." Almost 400 individual improvements[3] are recommended as listed in Exhibit 3-3, 25 percent of them in active warning device categories. Also, it will require a more extensive long-range effort if it is developed to its full potential as discussed in Chapter 2.

Exhibit 3-3
CENTRAL ROUTE CROSSING IMPROVEMENT RECOMMENDATIONS

IMPROVEMENT	PLAN RECOMMENDATIONS			
	Immediate	Six-Year	Long-Range	Totals
Lengthen Gates/Add Median Barrier	--	96 (1)	--	96 (1)
Add Lights & Gates	2 (0)	7 (0)	50 (4)	59 (4)
Add Gates	2 (0)	6 (0)	--	8 (0)
Install Quad Gates	--	20 (0)	2 (0)	22 (0)
Add Stop Signs	26 (34)	--	--	26 (34)
Close Crossing	--	34 (11)	5 (2)	39 (3)
Grade Separation	--	--	21 (0)	21 (0)
Reconstruct Crossing	1 (0)	4 (0)	--	5 (0)
Eliminate "Hump" – Improve Approaches	--	28 (10)	--	28 (10)
Install Traffic Signal	--	9 (0)	1 (0)	10 (0)
Install Manual Gates	--	--	0 (32)	0 (32)

Note: Public (Private)

Closure recommendations total 39 public and 3 private. These modifications represent 20 percent and 7 percent of each respective total, below target goals. Future planning efforts should identify additional opportunities.

[3] The number of improvements out number the number of crossings as some crossings are subjected to multiple treatments, e.g., improve warning devices and approaches.

Upstate Route – The Upstate Route, due to the more urbanized nature of large portions of its territory, and the larger number of trains using the line, already has a good level of active warning devices. By the same token, however, these same characteristics will dictate even higher levels with the introduction of additional and faster passenger trains. Based on the analysis contained in Chapter 2, the passenger train speeds will not, however, increase to the level anticipated for the Central Corridor.

The over 200 crossing improvements recommended for the route are shown in Exhibit 3-4. Very few of them involve active protection. Thirty-eight public crossings are recommended for closure, and seven private crossings. The recommendations comprise 38 percent and 35 percent of each category, respectively.

Exhibit 3-4
UPSTATE ROUTE CROSSING IMPROVEMENT RECOMMENDATIONS

	PLAN RECOMMENDATIONS			
IMPROVEMENT	**Immediate**	**Six-Year**	**Long-Range**	**Totals**
Lengthen Gates/Add Median Barrier	--	61 (1)	--	61 (1)
Add Lights & Gates	2 (0)	--	6 (1)	8 (1)
Add Gates	--	--	--	0 (0)
Install Quad Gates	--	17 (0)	--	17 (0)
Add Stop Signs	10 (13)	--	--	10 (13)
Close Crossing	--	27 (7)	11 (0)	38 (7)
Grade Separation	--	--	12 (0)	12 (0)
Reconstruct Crossing	--	2 (0)	--	2 (0)
Eliminate “Hump” – Improve Grades	1 (0)	37 (2)	--	38 (2)
Install Traffic Signal	--	1(0)	9 (0)	10 (0)
Install Manual Gates	--	--	0 (9)	0 (9)

Public (Private)

Chapter 4
PLAN DEVELOPMENT

Three plans are developed for the South Carolina SEHSR Corridor segments. They follow the Federal Highway Administration guidelines for development of a grade crossing improvement program in concert with the development of high-speed rail passenger service.

Corridor Segmentation

Initially the two routes were divided into three segments each as shown in Exhibit 4-1.

Exhibit 4-1
CORRIDOR SEGMENTATION

SEGMENT	LIMITS
Central Route	NC State line to Columbia Urban Area
	Columbia Urban Area
	Columbia Urban Area to GA State Line
Upstate Route	NC/SC State line to Spartanburg County Line
	Spartanburg and Greenville Counties
	Greenville County line to GA State Line

The purpose of the approach was to divide the routes into similar rural and urban sections. The concept for urban areas was expected to operate with reduced running speeds as is the practice in Europe, or bypasses would be constructed to maintain speed. In reality, the Central Route possesses different characteristics by segment as outlined. The Upstate Route, however, is more or less uniform throughout its traverse of South Carolina.

Plan Elements

Federal Highway Administration Guidelines for preparation of plans under Section 1103(c) of TEA-21, Railway-Highway Crossing Hazard Elimination in High Speed Rail Corridors, call for development of three plans which comprise three phases of the comprehensive plan. There is a long-range element, a six-year element, and an immediate element.

Long-Range Plan – This element can be conceptual and strategic and should cover a time period of 15-20 years. It should address rail alignment and equipment as well as at-grade crossings.

Six-Year Plan – This plan was to address projects for the six years of TEA-21. However, as there are only two years currently left for TEA-21, the six-year element for this study covers the time period but becomes basically a short-range plan. Crossings considered to be marginally safe should be addressed in this period.

Immediate Plan – This plan should be developed from a prioritized six-year plan. It should contain site-specific projects with cost estimates for which funding will be requested.

South Carolina Recommendations

The long-range objective of the four-state SEHSR coalition is to provide 110-mph rail passenger service along the designated corridors. South Carolina, as a member of the coalition, has the same objective. Improvements to meet these objectives over time fall into three categories – track, equipment and crossings. The plans developed in this study and discussed below are going to be subject to an evolving process as the implementation process is initiated and the work effort becomes more detailed.

Track – At the onset of this planning effort, the intent was to use existing rail lines in the designated corridors. These rail lines have been described in earlier sections of this report. The NS line, the Upstate Route, a heavily used freight route with alignment characteristics not conducive to high-speed operations, will require the greatest effort to meet SEHSR goals. In fact, a new alignment for all or large segments of the route will have to be considered long range if the top speed goal is to be met. Based on preliminary evaluations conducted as part of this effort, land development and population patterns in the area will make this a difficult task.

The Central Route is a more lightly used line and one which has promise for higher speed operations. While some major realignments are necessary north of Columbia, target speeds can be obtained south of Columbia with less drastic measures. Land development and population along the northern portion of the route are conducive at the present for the necessary realignments.

The following steps would comprise track-related elements for long-range development of high-speed service over the next 6 years.

Both Routes

1. Continue coordination with other coalition states to develop and progress a unified plan.
2. Establish contacts for project progression and technical matters with both CSXT and NS.
3. Proceed with the more easily accomplished speed improvements, e.g., turnout replacements, removal of municipal restrictions, increases in curve superelevation, etc. These improvements will provide immediate benefits for existing rail passenger service over both routes upon implementation.

Upstate Route

1. Conduct operating simulations on the existing Upstate Route for purposes of determining possible operating speeds and capacity under existing and future scenarios for both freight and passenger service.
2. Evaluate the potential to create a new alignment in the Upstate and proceed with engineering and environmental processes given favorable results.

Central Route

1. Advance the engineering and environmental evaluation of segment realignments suggested for the Central Route in this study.
2. Begin rail replacement with appropriate timbering and surfacing north of Columbia.

Equipment – The use of existing alignments virtually dictates adoption of tilt-train technology. Tilting equipment permits the increased operating speeds through curves immediately without realignment and minimizes realignment needs. Speed increases of up to 30 percent through curves on the average are possible. In particular, the state should:

1. Follow development of tilt equipment for use in the U.S. so that it will be in a position to make informed decisions when equipment needs are to be met.
2. Promote the FRA's development of a non-electric locomotive capable of sustaining target operating speeds.
3. Develop the necessary agreements for joint acquisition and operation with the other coalition states.

Crossings – The long-range plan is designed to meet corridor goals of at-grade crossing eliminations through closures and separations where appropriate. Improvements in warning devices are designated at remaining at-grade crossings. A summary of the effort for the three planning stages by route was the subject of Exhibits 3-3 and 3-4. A summary by county is contained in Appendix A.

As community consent will be needed to effect the at-grade crossing closures, it would be advantageous to begin immediately to establish working groups to address crossings at the local level. Such an effort has the potential to provide benefits for both the public and the railroads regardless of the ultimate development of the high-speed effort.

Chapter 5
COST ESTIMATES

Costs were estimated for rail line improvements -- rail infrastructure and grade crossings -- discussed in preceding chapters. The estimates are intended to provide a budget for immediate and six-year plans, and an order-of-magnitude assessment of long-range funding needs. Equipment or rolling stock costs are not included as these costs would be shared with other participants. The same holds true for equipment maintenance and servicing facilities.

Level of Accuracy

Capital cost estimates are typically prepared in a series of stages, each based on a more detailed level of design analysis and, hence, each more reliable than the previous estimate. These progressive stages can be defined as:

?? **Reconnaissance** – Based on brief field investigation and review of existing mapping;

?? **Conceptual or Planning** – Design configuration developed from initial engineering analysis, existing large-scale mapping and limited site verification, without detailed surveys;

?? **Preliminary Engineering** – Basic dimensioning and design features established based on project-specific surveys and mapping; and

?? **Final Design** – Complete design, ready for construction. This cost estimate is usually referred to as an Engineer's Estimate.

To provide as reliable an estimate as possible at each of these stages, a contingency allowance is usually added to the basic estimate, decreasing in magnitude as design details improve. The normal contingency rate is 40 – 50 percent at the reconnaissance level to 10 - 15 percent at the Final Design level.

The capital cost estimates for this study are based on an engineering analysis which could probably be characterized as lying between the Reconnaissance and Conceptual or

Planning level. Capital costs were developed from estimated quantities of work and unit prices derived specifically for this study.

Unit Costs

Unit costs were developed for track and signal work. Signal work is comprised of train control and at-grade rail-highway warning devices. The unit costs are shown in Exhibit 5-1.

Not included in the signal costs for the train control system for over 80-mph operation, however, is the cost to equip locomotives with the necessary devices. Equipment needs apply to freight locomotives operating over the route as well as passenger motive power. Costs would range between $25,000 and $100,000 per unit depending on the actual system adopted. The railroad would have to either equip all of its power or assign certain units to operate over the high-speed route. The latter requires locomotive changes, increasing costs and restricting operating flexibility.

Route Estimates

The capital cost estimates were prepared for each route based on the improvements discussed in the previous two chapters.

Upstate Route – The capital costs associated with the Upstate Route are small, comparatively speaking, as the goal for this route in terms of operating speed is to increase the average, not the maximum. This goal will be met principally through the use of tilting passenger equipment.

The estimate of capital costs is contained in Exhibit 5-2. As evident from examination of the exhibit, the largest share of the $145-million estimate is attributable to grade crossing improvements, namely grade separations. As expressed earlier, track improvements relate largely to added capacity and consist of replacement of part of the former second main track.

Central Route – Unlike the Upstate Route, the largest portion (almost 70 percent) of the $742-million cost estimate (see Exhibit 5-3) is dedicated to speed improvements. Capacity and

Exhibit 5-1
ESTIMATED UNIT COSTS

Category	Item	Unit	Estimated Cost
Track	High Speed Turnouts w/c.p.	ea.	$500,000.00
	Rail Replacement, new	mi.	335,000.00
	Concrete Tie Installation	TF	45.00
	Improve Class 4 Track to Class 6	TF	16.00
	Construct New Track	mi.	640,000.00
	Minor Realignment	mi.	1,300,000.00
	Major Realignment	mi.	2,000,000.00
	New Roadbed Adjacent to Existing	mi.	670,560.00
	Realign Track(1)	TF	17.00
	Surface Track w/ballast	TF	6.40
Signals	New Train Control System(2)	mi.	$450,000.00
	Electric Locks	ea.	$67,000.00
	Warning Device with FL & G(3)	per crossing	165,000.00
	Upgrade FL with Gates	per crossing	165,000.00(4)
	Lengthen Gate Arms	per crossing	2,500.00
	Improve 2 Gates to Quad Gates	per crossing	165,000.00
	Add Stop Signs	per crossing	500.00
	Crossing Closure	per crossing	25,000.00
	Grade Separation	per crossing	5,000,000.00
	Reconstruct Crossing	per crossing	11,000.00
	Improve “Hump” Crossings	per crossing	40,000.00
	Install Traffic Signal	per crossing	45,000.00
	Install Manual Gates	per crossing	5,000.00
	Relocate Crossing Active Device	per crossing	10,000.00
Other	Utility and Culvert Adjustments	mi.	$160,000.00
	Fiber Optic Relocation	mi.	150,000.00
	Acquire Right-of-Way, Rural	Ac.	15,000.00
	Acquire Right-of-Way, Urban	Ac.	60,000.00
	Construct Grade Crossing	TF	300.00
	Railroad Bridge	TF	3,000.00
	Station and Parking	ea.	1,250,000.00

(1) On existing roadbed.
(2) With provision for cab signals or automatic train stop.
(3) FL & G – Flashing lights and gates.
(4) Based on SCDOT experience

ea – each
mi – mile
TF – Track Foot
Ac. – Acre

Source: Wilbur Smith Associates
ABC-NACO

Exhibit 5-2
COST ESTIMATE
Upstate Route

SPEED IMPROVEMENTS (Maximum 79 MPH)

ITEM	**COST (Millions)**
1. Convert Equilateral TOs	$2.5
2. Realign Curves	2.2
3. Increase Superelevation	1.0
4. Electric Locks	0.5
Subtotal	$6.2
Engr & Cont	2.5
Total	$8.7
CAPACITY IMPROVEMENTS	
1. Second Main Track	$17.1
2. Connections & Crossovers	3.1
3. Utility Adjustments	3.2
4. Fiber Optic Cable Relocations	3.0
Subtotal	$26.4
Engr & Cont	10.6
Total	$37.0
GRADE CROSSING IMPROVEMENTS	
1. Immediate	$0.4
2. Six-Year	5.4
3. Long-Range	61.9
Subtotal	$67.7
Engr & Cont	27.1
Total	$94.8
OTHER	
Stations and Parking[(1)] (including Engr & Cont)	4.4
Route Total	$144.9

(1) One-half of costs for five unspecified locations.

Exhibit 5-3
COST ESTIMATE
Central Route

SPEED IMPROVEMENTS (Maximum 110 MPH)

ITEM	COST (Millions)
1. Replace Rail North End	$31.6
2. Class 4 track to Class 6	3.1
3. Concrete Tie Installation	46.7
4. Alignment Changes (minor and major)	134.8
5. Train Control System (cab signals)	88.4
6. Utility Adjustments	10.5
7. Fiber Optic Cable Relocation	9.9
8. Right-of-Way	26.5
Subtotal	$351.5
Engr & Cont	140.6
Total	$492.1
CAPACITY IMPROVEMENTS	
1. Construct Sidings	$37.6
2. Utility Adjustments	7.0
3. Relocate Fiber Optic Cable	6.5
Subtotal	$51.1
Engr & Cont	20.4
Total	$71.5
GRADE CROSSING IMPROVEMENTS	
1. Immediate	$0.7
2. Six-Year	8.8
3. Long-Range	114.6
Subtotal	$124.1
Engr & Cont	49.6
Total	$173.7
OTHER	
Stations and Parking[(1)] (including Engr & Cont)	4.4
Route Total	$741.7

(1) One-half of costs for five unspecified locations.

grade crossing improvements comprise 9.7 and 23.4 percent, respectively, of the total estimated cost.

Plan Funding Needs

Exhibits 5-1 and 5-2 depict total funding needs. Needs by plan component, i.e., immediate, six-year, and long-range, however, are not shown in the exhibits.

The breakdown of the grade crossing costs over time has already been discussed. Track-related capital improvements are mostly long-range, but some intermediate efforts are desirable, and in some cases, such as planning and engineering, are necessary to progress the long-range plan.

Continuation of this planning effort with train simulations and commencement of more detailed evaluations of potential realignments would fall into the immediate category. The engineering and environmental effort would continue into the six-year effort, with perhaps some right-of-way acquisition if engineering and environmental efforts progress far enough. The more easily implemented improvements such as increases in superelevation of existing curves not to be realigned, minor realignments, replacement of equilateral turnouts on the Upstate Route, rail replacement on the Central Route, and removal of municipal restrictions in combination with the grade crossing improvement program would also be implemented within this period. As noted previously, these improvements will provide immediate benefits for existing passenger service.

The remainder of the improvements would fall into the long-range category. Priorities for implementation would constitute part of the continuing planning effort. Funding needs to adhere to this schedule over time are the subject of Exhibit 5-4.

Exhibit 5-4
PLAN COMPONENT FUNDING NEEDS

Component	Estimated Costs
Immediate	$1.2
Six-Year	147.7
Long-Range	737.7
TOTAL	$886.6

Chapter 6
CHARLOTTE – COLUMBIA CORRIDOR

Although not an official component of the Southeast High Speed Rail Corridor, the Charlotte-Columbia Corridor frequently is mentioned as a connecting link both for the SEHSR Corridor and existing conventional Amtrak service. It also is a critical element of the I-77 Corridor Initiative. A cursory examination of the route was made for this study effort.

Route Characteristics

The route is Norfolk Southern's "R" line which runs 107.3 miles from Charlotte Junction to Columbia's Amtrak Station (see Exhibit 6-1). Charlotte Junction is 4.6 miles from Charlotte along the NS Washington – Atlanta main track, the same line that traverses the Upstate. The North Carolina – South Carolina border is 11.5 miles from Charlotte Junction, or 95.8 miles from Columbia. The line runs through Fort Mill, Rock Hill, Chester, Winnsboro, Ridgeway and Blythewood en route from Charlotte to Columbia.

Line Use – The route has become more heavily used by NS in the last decade, and now is traversed by 9 to 11 freight trains per day. Passenger trains have not operated on the line in some years.

Train Control – Operations on the line are governed by an automatic block signal system.

Operating Speed – Freight lines are currently operated at a maximum timetable speed of 50 mph although there are numerous restrictions due to curvature. In all, speed is restricted to less than maximum speeds over 33 miles of the route.

Track Characteristics – The track is laid with 132-lb continuous welded rail and meets FRA Class 4 criteria.

Exhibit 6-1

Improvements Needed

Speed Improvements – The line is in many ways similar to the Upstate Route. It is in good condition, but its geometry limits operating speeds. Also, due to the reduced maximum speed as compared to the Upstate Route, curve superelevation tends to run about one inch less for comparable curves. For passenger operation at higher speeds, the superelevation should be increased and tilt equipment acquired for use on the route. Strategic curve realignments are possible, but will be expensive due to the rough terrain.

Capacity Improvements – Additional sidings will be necessary to increase the capacity of the single-track line, the number of which are dependent on the number of passenger trains and future freight operations.

Fairwold Connector – The Fairwold Connector is an unimplemented component of the Columbia Grade Crossing Elimination project. It would provide a connection between the NS Charlotte-Columbia line and CSXT's "S" line near the intersection of Fontaine Road and SC Route 555. The connection would permit trains operating over NS to reach the Columbia Amtrak station by a less circuitous route than continuing over the NS line which runs through the Five Points area. It would also keep passenger trains pointed in the right direction, whereas the all – NS route would require a backing move at some point.

Grade Crossings – There are 118 rail-highway crossings on the line with 14 of them grade separated. Crossings per mile therefore average around one per mile, comparable with the two designated high-speed routes. Consolidation and improvement of crossings would need to be undertaken, and starts for active warning devices would have to be modified for the faster passenger train speeds.

Network Fit

As stated earlier, the line segment would connect the two routes of the SEHSR Corridor. It has also been suggested that it be developed as part of the Central route in lieu of the Raleigh-Columbia segment of the "S" line. The route, however, would be 60 miles (or 30 percent) longer than the more direct "S" line between Raleigh and Columbia, and due to alignment considerations, negate the potential for faster running over the “S” line, at least in South Carolina.

Conclusion

With improvements, the NS line between Charlotte and Columbia line could be made into a 79-mile per hour route, but higher speeds would require major realignments, or more practically, a new alignment.

APPENDIX

CENTRAL ROUTE
(CSXT)

ALLENDALE COUNTY	GRADE CROSSING RECOMMENDATIONS			
Type Treatment	Immediate	Six Year	Long Range	Totals
Lengthen Gates/Add Median Barrier	_	9 (0)	_	9 (0)
Add Signals & Gates	_	_	6 (2)	6 (2)
Add Gates	_	_	_	0 (0)
Install Quad Gates	_	_	2 (0)	2 (0)
Add Stop Signs	1 (5)	_	_	1 (5)
Close Crossing	_	5 (3)	_	5 (3)
Grade Separation	_	_	1 (0)	1 (0)
Reconstruct Crossing	_	2 (0)	_	2 (0)
Eliminate "Hump" - Improve Grades	_	1 (0)	_	1 (0)
Install Traffic Signal	_	2 (0)	_	2 (0)
Install manual Gates	_	_	0 (3)	0 (3)
Public (Private)				

CENTRAL ROUTE
(CSXT)

BAMBERG COUNTY	GRADE CROSSING RECOMMENDATIONS			
Type Treatment	Immediate	Six Year	Long Range	Totals
Lengthen Gates/Add Median Barrier	_	8 (0)	_	8 (0)
Add Signals & Gates	_	1 (0)	12 (0)	13 (0)
Add Gates	_	2 (0)	_	2 (0)
Install Quad Gates	_	3 (0)	_	3 (0)
Add Stop Signs	8 (4)	_	_	8 (4)
Close Crossing	_	6 (1)	_	6 (1)
Grade Separation	_	_	1 (0)	1 (0)
Reconstruct Crossing	_	_	_	0 (0)
Eliminate "Hump" - Improve Grades	_	3 (1)	_	3 (1)
Install Traffic Signal	_	1 (0)	1	2 (0)
Install Manual Gates	_	_	0 (4)	0 (4)
Public (Private)				

CENTRAL ROUTE
(CSXT)

CHESTERFIELD COUNTY	GRADE CROSSING RECOMMENDATIONS			
Type Treatment	Immediate	Six Year	Long Range	Totals
Lengthen Gates/Add Median Barrier	_	10 (0)	_	10 (0)
Add Signals & Gates	_	1(0)	7 (0)	8 (0)
Add Gates	1 (0)	_	_	1 (0)
Install Quad Gates	_	4 (0)	_	4 (0)
Add Stop Signs	9 (3)	_	_	9 (3)
Close Crossing	_	5 (0)	2 (0)	7 (0)
Grade Separation	_	_	4 (0)	4 (0)
Reconstruct Crossing	_	1 (0)	_	1 (0)
Eliminate "Hump" - Improve Grades	_	6 (2)	_	6 (2)
Install Traffic Signal	_	_	_	0 (0)
Install Manual Gates	_	_	0 (3)	0 (3)
Public (Private)				

CENTRAL ROUTE
(CSXT)

HAMPTON COUNTY	GRADE CROSSING RECOMMENDATIONS			
Type Treatment	Immediate	Six Year	Long Range	Totals
Lengthen Gates/Add Median Barrier	_	15 (0)	_	15 (0)
Add Signals & Gates	_	_	6 (1)	6 (1)
Add Gates	_	_	_	0 (0)
Install Quad Gates	_	2 (0)	_	2 (0)
Add Stop Signs	3 (12)	_	_	3 (12)
Close Crossing	_	3 (3)	_	3 (3)
Grade Separation	_	_	_	0 (0)
Reconstruct Crossing	_	_	_	0 (0)
Eliminate "Hump" - Improve Grades	_	4 (3)	_	4 (3)
Install Traffic Signal	_	3 (0)	_	3 (0)
Install manual Gates	_	_	0 (10)	0 (10)
Public (Private)				

CENTRAL ROUTE
(CSXT)

JASPER COUNTY	GRADE CROSSING RECOMMENDATIONS			
Type Treatment	Immediate	Six Year	Long Range	Totals
Lengthen Gates/Add Median Barrier	_	1 (0)	_	1 (0)
Add Signals & Gates	_	_	_	0 (0)
Add Gates	_	_	_	0 (0)
Install Quad Gates	_	_	_	0 (0)
Add Stop Signs	_	_	_	0 (0)
Close Crossing	_	_	_	0 (0)
Grade Separation	_	_	_	0 (0)
Reconstruct Crossing	_	_	_	0 (0)
Eliminate "Hump" - Improve Grades	_	_	_	0 (0)
Install Traffic Signal	_	_	_	0 (0)
Install manual Gates	_	_	0 (1)	0 (1)
Public (Private)				

CENTRAL ROUTE
(CSXT)

KERSHAW COUNTY	GRAD			
Type Treatment	Immediate	Six Year	Long Range	Totals
Lengthen Gates/Add Median Barrier	_	15 (0)	_	15 (0)
Add Signals & Gates	_	2 (0)	4 (1)	6 (1)
Add Gates	_	2 (0)	_	2 (0)
Install Quad Gates	_	2 (0)	_	2 (0)
Add Stop Signs	0 (4)	_	_	0 (4)
Close Crossing	_	2 (0)	0 (1)	2 (1)
Grade Separation	_	_	_	0 (0)
Reconstruct Crossing	_	_	_	0 (0)
Eliminate "Hump" - Improve Grades	_	4 (3)	_	4 (3)
Install Traffic Signal	_	_	_	0 (0)
Install Manual Gates	_	_	0 (4)	0 (4)
Public (Private)				

CENTRAL ROUTE
(CSXT)

LEXINGTON COUNTY	GRADE CROSSING RECOMMENDATIONS			
Type Treatment	Immediate	Six Year	Long Range	Totals
Lengthen Gates/Add Median Barrier	_	9 (1)	_	9 (1)
Add Signals & Gates	1 (0)	3 (0)	6 (0)	10 (0)
Add Gates	_	_	_	0 (0)
Install Quad Gates	_	3 (0)	_	3 (0)
Add Stop Signs	1 (0)	1 (0)	_	2 (0)
Close Crossing	_	1 (0)	2 (0)	3 (0)
Grade Separation	_	_	1 (0)	1 (0)
Reconstruct Crossing	_	_	_	0 (0)
Eliminate "Hump" - Improve Grades	_	3 (0)	_	3 (0)
Install Traffic Signal	_	_	_	0 (0)
Install Manual Gates	_	_	_	0 (0)
Public (Private)				

CENTRAL ROUTE
(CSXT)

MARLBORO COUNTY	GRADE CROSSING RECOMMENDATIONS			
Type Treatment	Immediate	Six Year	Long Range	Totals
Lengthen Gates/Add Median Barrier	_	3 (0)	_	3 (0)
Add Signals & Gates	_	_	_	0 (0)
Add Gates	_	_	_	0 (0)
Install Quad Gates	_	_	_	0 (0)
Add Stop Signs	_	_	_	0 (0)
Close Crossing	_	1 (0)	_	1 (0)
Grade Separation	_	_	_	0 (0)
Reconstruct Crossing	_	_	_	0 (0)
Eliminate "Hump" - Improve Grades	_	_	_	0 (0)
Install Traffic Signal	_	_	_	0 (0)
Install Manual Gates	_	_	_	0 (0)
Public (Private)				

CENTRAL ROUTE
(CSXT)

RICHLAND COUNTY	GRADE CROSSING RECOMMENDATIONS			
Type Treatment	Immediate	Six Year	Long Range	Totals
Lengthen Gates/Add Median Barrier	_	14 (0)	_	14 (0)
Add Signals & Gates	_	_	_	0 (0)
Add Gates	2 (0)	1 (0)	_	3
Install Quad Gates	_	3 (0)	_	3 (0)
Add Stop Signs	0 (1)	_	_	0 (1)
Close Crossing	_	5 (3)	1 (1)	6 (4)
Grade Separation	_	_	14 (0)	14 (0)
Reconstruct Crossing	_	1 (0)	_	1 (0)
Eliminate "Hump" - Improve Grades	_	_	_	0 (0)
Install Traffic Signal	_	_	_	0 (0)
Install Manual Gates	_	_	0 (1)	0 (1)
Public (Private)				

UPSTATE ROUTE
(Norfolk Southern)

CHEROKEE COUNTY	GRADE CROSSING RECOMMENDATIONS			
Type Treatment	Immediate	Six Year	Long Range	Totals
Lengthen Gates/Add Median Barrier	_	16 (0)	_	16 (0)
Add Signals & Gates	_	_	2 (0)	2 (0)
Add Gates	_	_	_	0 (0)
Add Quad Gates	_	4 (0)	_	4 (0)
Add Stop Signs	4 (6)	_	_	4 (6)
Close Crossing	_	11 (4)	10 (0)	21 (4)
Grade Separation	_	_	3 (0)	3 (0)
Reconstruct Crossing	_	1 (0)	_	1(0)
Eliminate "hump" - Improve Grades	_	10 (0)	0 (1)	10 (1)
Add Traffic Signal	_	_	_	0 (0)
Add Manual Gates	_	_	0 (4)	0 (4)
Public (Private)				

UPSTATE ROUTE
(Norfolk Southern)

GREENVILLE COUNTY	GRADE CROSSING RECOMMENDATIONS			
Type Treatment	Immediate	Six Year	Long Range	Totals
Lengthen Gates/Add Median Barrier	_	10 (1)	_	10 (1)
Add Signals & Gates	_	_	_	0 (0)
Add Gates	_	_	_	0 (0)
Install Quad Gates	_	3 (0)	_	3 (0)
Add Stop Signs	_	_	_	0 (0)
Close Crossing	_	5 (0)	1 (0)	6 (0)
Grade Separation	_	_	3 (0)	3 (0)
Reconstruct Crossing	_	_	_	0 (0)
Eliminate "Hump" - Improve Grades	_	5 (0)	_	5 (0)
Install Traffic Signal	_	_	_	0 (0)
Install manual Gates	_	_	_	0 (0)
Public (Private)				

UPSTATE ROUTE
(Norfolk Southern)

OCONEE COUNTY	GRADE CROSSING RECOMMENDATIONS			
Type Treatment	Immediate	Six Year	Long Range	Totals
Lengthen Gates/Add Median Barrier	_	7 (0)	_	7 (0)
Add Signals & Gates	_	_	1 (1)	1 (1)
Add Gates	_	_	_	0 (0)
Install Quad Gates	_	_	_	0 (0)
Add Stop Signs	3 (2)	_	_	3 (2)
Close Crossing	_	3 (1)	_	3 (1)
Grade Separation	_	_	2 (0)	2 (0)
Reconstruct Crossing	_	_	_	0 (0)
Eliminate "Hump" - Improve Grades	_	3 (0)	_	3 (0)
Invetsigate Traffic Signal	_	_	2 (0)	2 (0)
Install manual Gates	_	_	0 (2)	0 (2)
Add Crossbucks	0 (1)	_	_	0 (1)
Public (Private)				

UPSTATE ROUTE
(Norfolk Southern)

PICKENS COUNTY	GRADE CROSSING RECOMMENDATIONS			
Type Treatment	Immediate	Six Year	Long Range	Totals
Lengthen Gates/Add Median Barrier	_	14 (0)	_	14 (0)
Add Signals & Gates	2 (0)	_	1 (0)	3 (0)
Add Gates	_	_	_	0 (0)
Install Quad Gates	_	3 (0)	_	3 (0)
Add Stop Signs	1 (2)	_	_	1 (2)
Close Crossing	_	3 (4)	_	3 (4)
Grade Separation	_	_	1 (0)	1 (0)
Reconstruct Crossing	_	_	_	0 (0)
Eliminate "Hump" - Improve Grades	1 (0)	10 (1)	_	11 (1)
Install Traffic Signal	_	_	4 (0)	4 (0)
Install manual Gates	_	_	0 (1)	0 (1)
Public (Private)				

UPSTATE ROUTE
(Norfolk Southern)

SPARTANBURG COUNTY	GRADE CROSSING RECOMMENDATIONS			
Type Treatment	Immediate	Six Year	Long Range	Totals
Lengthen Gates/Add Median Barrier	_	14 (1)	_	14 (1)
Add Signals & Gates	_	_	2 (0)	2 (0)
Add Gates	_	_	_	0 (0)
Install Quad Gates	_	7 (0)	_	7 (0)
Add Stop Signs	2 (3)	_	_	2 (3)
Close Crossing	_	4 (2)	_	4 (2)
Grade Separation	_	_	6 (0)	6 (0)
Reconstruct Crossing	_	2 (0)	_	2 (0)
Eliminate "Hump" - Improve Grades	_	9 (1)	_	9 (1)
Investigate Traffic Signal	_	1 (0)	3 (0)	4(0)
Install manual Gates	_	_	(0) 2	(0) 2
Public (Private)				