



American Railway Engineering and
Maintenance-of-Way Association

CHAPTER 17

COMMUTER, PASSENGER AND HIGH SPEED RAIL¹

Current until revision of next edition

FOREWORD

This Chapter contains AREMA recommended practice with respect to the planning, engineering, construction and maintenance of commuter, passenger and high speed rail systems. It also includes recommendations relative to an incremental approach such as the upgrading of existing facilities for increased speeds, recognizing the possible joint use by freight and passenger services. These joint usage issues should be addressed at the preliminary planning stage. The manual, as it is now structured, is not stratified by speed ranges, but rather by the function of the facility or component. Where speeds are a factor of the element upper limits are not stressed. The purpose of this chapter is to identify the applicable speeds for the elements in the manual common to this chapter and use them as a base for developing high speed criteria. The speed range stratification starts with that practical, given the limitations of existing facilities, to the super speeds of new facilities.

Chapter 17 considers present foreign high speed rail technical capabilities and operating characteristics and extrapolates them to North American passenger and freight railroad experience to develop recommended practice for high speed rail systems. Previous experience with imported technologies and practices has shown that modifications are often needed to successfully adapt them to the climatic, maintenance, operating, and regulatory environments found in North America.

System safety parameters, economics, and design philosophies must also be evaluated in the North American context.

The traditional manual material, for the most part, contains “stand-alone” recommended practices for the fixed plant of railways. This Chapter encompasses high speed rail as a system; i.e., combining the planning, design, and construction of the facility with the specification and operating characteristics of the vehicle, including propulsion and control system considerations.

¹ The material in this and other chapters in the *AREMA Manual for Railway Engineering* is published as recommended practice to railroads and others concerned with the engineering, design and construction of railroad fixed properties (except signals and communications), and allied services and facilities. For the purpose of this Manual, RECOMMENDED PRACTICE is defined as a material, device, design, plan, specification, principle or practice recommended to the railways for use as required, either exactly as presented or with such modifications as may be necessary or desirable to meet the needs of individual railways, but in either event, with a view to promoting efficiency and economy in the location, construction, operation or maintenance of railways. It is not intended to imply that other practices may not be equally acceptable.

FOREWORD (CONT)

The Chapter is divided into three parts:

1. Corridor Evaluation.
2. Track Structures and Train Interactions.
3. Vehicle, Control and Propulsion Systems Consideration.

There are subparts of the Chapter that are the same as existing recommendations in the manual and where this occurs a reference is made to the existing Chapter and paragraph number. New and existing material that requires technical enhancement is presented based on existing high speed rail systems and the expertise of committee members.

TABLE OF CONTENTS

Part/Section	Description	Page
1 Corridor Evaluation		17-1-1
1.1	Introduction	17-1-3
1.2	Preliminary Evaluation	17-1-4
1.3	Geographical Evaluation	17-1-7
1.4	Operational Analysis	17-1-15
1.5	Financial Evaluation	17-1-17
1.6	Incremental High-Speed Corridors (1998)	17-1-20
1.7	Incremental Corridor Analyses (1998)	17-1-26
1.8	Documentation of Recommended Improvements (1998)	17-1-37
1.9	Grade Crossings in Incremental High-Speed Corridors (1998)	17-1-38
1.10	Systematic Grade Crossing Evaluation Methodology	17-1-39
1.11	Results of Grade Crossing Evaluation	17-1-40
1.12	Alignment Terminology	17-1-40
2 Track Structures and Train Interactions		17-2-1
2.1	Introduction	17-2-2
2.2	Design Criteria	17-2-2
2.3	Right-of-Way	17-2-2
2.4	Track	17-2-3
2.5	Structures	17-2-11
2.6	Clearances	17-2-11
3 Vehicle, Control and Propulsion Systems Consideration		17-3-1
3.1	Introduction (1996)	17-3-2
3.2	General Requirements	17-3-2
3.3	Design Requirements	17-3-3
3.4	Rolling Stock	17-3-10
3.5	Control Systems	17-3-13
3.6	Electric Traction Power	17-3-26



INTRODUCTION

The Chapters of the AREMA Manual are divided into numbered Parts, each comprised of related documents (specifications, recommended practices, plans, etc.). Individual Parts are divided into Sections by centered headings set in capital letters and identified by a Section number. These Sections are subdivided into Articles designated by numbered side headings.



Page Numbers – In the page numbering of the Manual (17-2-1, for example) the first numeral designates the Chapter number, the second denotes the Part number in the Chapter, and the third numeral designates the page number in the Part. Thus, 17-2-1 means Chapter 17, Part 2, page 1.

In the Glossary and Bibliography, the Part number is replaced by either a “G” for Glossary or “B” for Bibliography.



Document Dates – The bold type date (Document Date) at the beginning of each document (Part) applies to the document as a whole and designates the year in which revisions were last made somewhere in the document, unless an attached footnote indicates that the document was adopted, reapproved, or rewritten in that year.

Article Dates – Each Article shows the date (in parenthesis) of the last time that Article was modified.



Revision Marks – All current year revisions (changes and additions) which have been incorporated into the document are identified by a vertical line along the outside margin of the page, directly beside the modified information.

Proceedings Footnote – The Proceedings footnote on the first page of each document gives references to all Association action with respect to the document.



Annual Updates – New manuals will be reprinted and issued yearly, in their entirety.

THIS PAGE INTENTIONALLY LEFT BLANK.





American Railway Engineering and
Maintenance-of-Way Association



Part 1

Corridor Evaluation¹

— 1999 —

TABLE OF CONTENTS

Section/Article	Description	Page
1.1 Introduction		17-1-3
1.1.1	General (1995)	17-1-3
1.2 Preliminary Evaluation		17-1-4
1.2.1	General (1995)	17-1-4
1.2.2	Demand for High Speed Rail Service (1995)	17-1-4
1.2.3	Institutional Factors (1995)	17-1-6
1.3 Geographical Evaluation		17-1-7
1.3.1	General (1995)	17-1-7
1.3.2	Alignment and Location (1995)	17-1-7
1.3.3	Location of Ancillary Facilities (1995)	17-1-9
1.3.4	Safety Factors (1995)	17-1-12
1.3.5	Environmental Factors (1995)	17-1-14
1.4 Operational Analysis		17-1-15
1.4.1	General (1995)	17-1-15
1.4.2	Train Schedules and Consists (1995)	17-1-15
1.4.3	Operating Speeds (1995)	17-1-15
1.4.4	Types of Equipment (1995)	17-1-16
1.4.5	Other Operating Issues (1995)	17-1-16
1.5 Financial Evaluation		17-1-17
1.5.1	General (1995)	17-1-17
1.5.2	Cost Analysis (1995)	17-1-17
1.5.3	Operating and Maintenance Costs (1995)	17-1-18
1.5.4	Financing Considerations and Alternatives (1995)	17-1-19
1.5.5	Cash Flow, Return on Investment and Other Financial Analysis (1995)	17-1-19

¹ References, Vol. 96, p. 77.

TABLE OF CONTENTS

Section/Article	Description	Page
1.6 Incremental High-Speed Corridors (1998).		17-1-20
1.6.1	General (1998)	17-1-20
1.6.2	Evaluation of Incremental High-Speed Rail Corridors (1998)	17-1-20
1.6.3	Existing Corridor Characteristics (1998)	17-1-21
1.7 Incremental Corridor Analyses (1998)		17-1-26
1.7.1	Increasing Train Speeds (1998)	17-1-26
1.7.2	Integration of IHSR Studies (1998)	17-1-26
1.7.3	Operations Analyses (1998)	17-1-27
1.7.4	Operations Analysis Models (1998)	17-1-27
1.7.5	Alignment Evaluations (1998)	17-1-27
1.7.6	Financial Evaluation (1998)	17-1-37
1.8 Documentation of Recommended Improvements (1998).		17-1-37
1.8.1	Individual Task Reports (1998)	17-1-37
1.8.2	Final Report (1998)	17-1-37
1.9 Grade Crossings in Incremental High-Speed Corridors (1998)		17-1-38
1.9.1	Increased Train Speeds and the Level of Grade Crossing Warning System Enhancements	17-1-39
1.10 Systematic Grade Crossing Evaluation Methodology		17-1-39
1.10.1	Review of Previous Data	17-1-39
1.10.2	Acquisition of Data	17-1-39
1.10.3	Discussions with Local Officials, County Engineers and Planners	17-1-39
1.10.4	Estimates of Proposed Train Speeds	17-1-39
1.10.5	Evaluation of Vehicular Traffic Demand, Roadway/Crossing Delay and Accident Data	17-1-40
1.10.6	Classification of Crossings by Function and Use	17-1-40
1.10.7	Estimate of Adverse Travel	17-1-40
1.10.8	Develop Preliminary Concepts and Grade Crossing Treatments	17-1-40
1.11 Results of Grade Crossing Evaluation		17-1-40
1.11.1	Information to be Provided	17-1-40
1.12 Alignment Terminology		17-1-40
1.12.1	Unbalanced Superelevation	17-1-40
1.12.2	Lateral Acceleration Parallel to the Vehicle's Floor Boards	17-1-40
1.12.3	The Comfort Transition Curve, Jerk, and Jolt	17-1-40

LIST OF FIGURES

Figure	Description	Page
1-1	Plot of Speed vs. Distance	17-1-31
1-2	TPC Simulation Report - Actual vs. Goal Speed	17-1-32
1-3	Simulation Stringline	17-1-38

LIST OF TABLES

Table	Description	Page
1-5	Simulated Run Times and Available Pad	17-1-33



SECTION 1.1 INTRODUCTION

1.1.1 GENERAL (1995)



- a. High Speed Rail for passenger service has been developed and proven in revenue service to be a highly successful technology, allowing speeds in excess of 186 mph (300 kph). In determining the need for and viability of a high speed rail system, a feasibility study is necessary. Such a study is often the function of a governmental agency working with firms or agencies which have the proper knowledge and experience in the development of such a passenger transportation system. Coordination with other rail users is necessary. An initial phase in determining feasibility of the high speed rail system is corridor evaluation. This part enumerates the factors to be considered in corridor evaluation and provides general guidelines for conducting the study. However, it must be recognized that each potential high speed route requires a site specific study, with many factors requiring in-depth evaluation. The conceptual plan to be developed entails a great amount of effort by a group of varied disciplines.
- b. Factors which must be considered in high speed rail corridor evaluation, that are further discussed in this Part are:
 - Demand for service—including both the transportation market and governmental policy.
 - Geographical.
 - Safety.
 - Environmental.
 - Operational.
 - Financial—including costs, revenues and availability of funds.
- c. This initial planning stage may require a number of years to complete. Demands for service may require marketing studies over a period of time. Financial projections and determining the availability of funds may present time-consuming problems. The need for government assistance in financing arrangements could require significant statutory revisions to provide government funding or to assist private organizations in raising necessary capital. Also, the issue of freight railroad indemnification must be addressed if high speed passenger trains are being planned to jointly operate on a line with freight train traffic.
- d. This part is not intended to address in-depth the technical aspects of engineering a high speed rail system. Subsequent parts will be more technically oriented. However, since corridor evaluation is the initial step in development of a system, when results are positive more detailed engineering should commence.

SECTION 1.2 PRELIMINARY EVALUATION

1.2.1 GENERAL (1995)

- a. High speed trains are capable of providing fast, reliable, safe, environmentally friendly and efficient transportation for large volumes of people. The design and implementation of a high speed rail service is a very complex process. However, before a high speed rail service can be designed, detailed analyses will be required to determine the demand, or number of patrons likely to use the service. The demand analysis will estimate the level to which a proposed system will be expected to cover its capital and operating expenses with operating revenue and growth potential. Consideration should also be given to the possibility of government participation and coordination with other transportation modes.
- b. Completion of the preliminary evaluation will mark the first milestone at which a “go” or “no-go” decision can be made with respect to the project.

1.2.2 DEMAND FOR HIGH SPEED RAIL SERVICE (1995)

1.2.2.1 Introduction

Demand for service is a key element in the planning and implementation of a high speed rail system. Planners and system operators must carefully balance the factors outlined below to develop a system that will have the greatest potential for economic viability.

1.2.2.2 Demand for Service in the Present Market

The demand for high speed rail service in the present market is a function of a number of factors such as the population and demographics of the corridor, and the efficiency of the existing transportation system. The market consists of travel for two primary purposes, business travelers and leisure travelers.

1.2.2.2.1 Total Number of Trips in Corridor

The demand for service is a function of the total number of trips in the corridor. The percentage of total trips taken on each available transportation mode is defined as the modal split. As the level of service of the high speed rail system increases relative to other modes, rail modal share can be expected to increase.

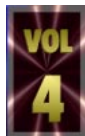
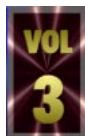
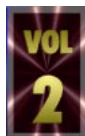
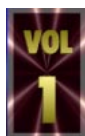
1.2.2.2.2 Fare Structure

- a. The fare structure chosen will have a large impact on the demand for service among certain travelers. In general terms, business travelers are more sensitive to the level of service than to cost. Studies indicate that line haul travel time is the major factor influencing modal choice among business travelers, and that they only slightly favor airlines over high speed rail if the two offered equivalent service and equivalent fares.
- b. Leisure travelers are more sensitive to cost than level of service, and in many cases would not leave their automobiles no matter what the fares were. Planners should carefully balance the fare structure to ensure that fares are attractive to an optimum number of travelers.

1.2.2.2.3 Level of Service

- a. The primary factor influencing demand for service among business travelers is the level of service. Level of service consists of several elements. The first is the technology chosen for the service. The technology chosen will control the line-haul travel time, which is the major consideration among business travelers. The second element is frequency of service. If a train is available every one to two hours, service is essentially considered to be available “on demand.”





- b. Line-haul travel time tends to be less important to leisure travelers than to business travelers. Leisure travelers value the flexibility that the automobile provides with respect to departure times, stops en route, travel route chosen, and most importantly, the cost advantage which the automobile generally provides over public transportation. However, leisure travelers should not be overlooked as potential users of a high speed rail system.
- c. Another element of the level of service is coordination with other modes at stations along the line. The schedules of commuter rail service, local bus service, and any other system should be coordinated with the high speed rail service to facilitate the ease of movement to the final destination. The availability of adequate parking facilities will impact demand favorably as well.
- d. The location of the stations within a given city, and along a given route will have an impact on the demand for service to that city. Demand for service will tend to be greater if the stations are located near the central business district, the airport, or other areas with high levels of commercial activity.

1.2.2.3 Demand for Service in the Future Market

1.2.2.3.1 Total Number of Trips in the Corridor

A high speed rail system will establish a ridership base during the early years of operation. Demand growth in the corridor will be a function of the growth in total number of trips in the corridor, future demographics, availability, cost and efficiency of alternative transportation modes, and the ability of the system to induce travelers to use the system. “Induced demand” is defined as trips which are not currently being made, but will be made in the future due to the presence of the high speed system. It does not include trips made because of normal growth of population or economic activity.

1.2.2.3.2 Fare Structure

The fare structure must remain competitive within the transportation market for the system to retain the traffic base it establishes in the early years of its operation.

1.2.2.3.3 Level of Service

Any improvements in the level of service tend to increase demand. Attitudes toward the service, developed as a result of the system performance, will have a large impact on the demand for service in the future market. As the system develops a reputation for providing a clean, reliable, comfortable, safe, and cost-effective service, demand for the service will increase.

1.2.2.4 Availability of Competitive Modes

1.2.2.4.1 Airlines

- a. Airline business travelers are extremely sensitive to terminal to terminal and door to door travel time. Studies indicate that they would tend to consider both airlines and high speed rail essentially as equal given equal levels of service. The most dominant factor influencing the level of demand among airline business travelers is the level of service. Therefore, given adequate levels of service and reliability, high speed rail systems could be expected to draw passengers from the airline mode. In addition, high speed rail service could be a complement to air service for business travelers by providing an efficient mode of transportation to an area that does not have full scale air service.
- b. Airline leisure travelers are more sensitive to travel cost than are airline business travelers. However, by virtue of the fact that leisure travelers choose to fly at their own expense, they clearly value the time savings. A high speed rail system can expect to draw passengers from airlines if the level of service is equal or similar to that of the airlines, and the fare structure is competitive with or lower than that of the airlines.

1.2.2.4.2 Automobile

- a. Travel time is less important to business travelers who drive than it is to those who fly. The drivers place a higher value on other aspects of automobile travel, such as privacy, cargo space, flexibility of departure times, and route selection.
- b. The line haul travel time for auto leisure travelers is generally less important than for business travelers.
- c. Leisure travelers will tend to be very sensitive to fare structures, and rather insensitive to travel time, as this group tends to most desire the aspects of travel provided by the automobile, such as privacy, flexibility of departure times and route selection, and stops en route.



1.2.3 INSTITUTIONAL FACTORS (1995)

The preliminary corridor evaluation should consider such things as government support and the relationship to other forms of transportation. It should also be sensitive to the political environment. These factors are of utmost importance in influencing the accomplishment of the project.



1.2.3.1 Government Agency Involvement

- a. Coordination with federal, state and local governments is essential and they are becoming increasingly aware of the important role they play in determining the transportation infrastructure within their jurisdiction. Their support should be sought with regard to funding through grants, loans, bond issues and other similar activities. Grants may encompass the transfer of property rights necessary to build the corridor. Government agencies' requirements regarding Environmental Impact Statements (EIS) must be determined and their support sought in the preparation of any required EIS.
- b. The proper coordination and involvement with government agencies in the preliminary evaluation will help to ensure a successful project.



1.2.3.2 Political Considerations

- a. The preliminary evaluation must be sensitive to the concerns of the residents along the right-of-way, and the surrounding environment as well as the future passengers. All political impacts must be considered. For this reason, a good public relations program is essential.
- b. The acquisition of land, by purchase or condemnation, and the impact on property values must be handled in a fair and equitable manner. The choice of station stops will be influenced by public demand and political preferences that may not always be the most economical, but nevertheless, must be considered.

1.2.3.3 Interface with Other Transportation Modes

- a. A primary consideration in the preliminary evaluation is the location of and access by or to other modes of transportation. The location of stations should fit the community needs and be convenient for transferring from and to commuter rail, rapid transit, air, bus and automobile.
- b. Intermodal stations should be developed for use of the traveling public. However, the number of stations and frequency of stops must not be allowed to degrade the goal of providing high-speed rail service with its accompanying reduced travel times. Different schedules for station stops may reduce impact on travel times, yet still provide coverage for a larger number of locations.

1.2.3.4 Liability

Freight railroads may desire to be indemnified for and insured against financial liability, regardless of cause, related to any passenger service that operates on the freight railroads tracks. This passenger service can be existing service, new service, or one that increases the maximum operating speed to be considered High Speed. It may be that the only fully satisfactory way to resolve this issue is through Federal legislation or use of completely separated rights-of-way.

SECTION 1.3 GEOGRAPHICAL EVALUATION

1.3.1 GENERAL (1995)

In the planning and development of a high speed rail line geographical considerations are of major importance. Whether it be a completely new right-of-way, use of existing right-of-way, or a combination of both, the factors in this section must be the subject of any in-depth study. Such an evaluation should address routes, location of facilities, safety factors, and environmental concerns. These items are addressed individually in the following articles.

1.3.2 ALIGNMENT AND LOCATION (1995)

1.3.2.1 Population and Employment Centers

- a. A saturation point is being reached with respect to population in many areas of North America. In 1990, 192.7 million people or 77.5% of the total population of the United States now live in 279 metropolitan areas that exceed 100,000 in population. One half of the U.S. population, 124.8 million people live and work in the top 39 metropolitan areas that have over one million residents.
- b. Economic and political decisions over the past 50 years have resulted in the major transition in passenger transportation mode from rail to airline and automotive modes. In the course of events this has resulted in significant airport and highway congestion. It has also brought about atmospheric pollution and rapid diminution of our energy resources.
- c. It appears that a reasonable solution to this problem that is encountered in the thickly populated areas could be a more intensive use of rail facilities. In addition to the utilization of rapid transit facilities within the urban areas, that is now being encouraged, a return to the research and development of high speed rail projects that was abandoned by the U.S. Government in the late '70's is desirable.
- d. A network of high speed rail projects linking most of the metropolitan areas is practical. Twenty-nine of the 39 largest metropolitan areas are located between the Atlantic coast and the Mississippi valley region, grouped so that corridors not exceeding 500 miles can be linked together. This will provide an intermodal passenger transportation system that could greatly alleviate the present undesirable conditions.

1.3.2.2 Geographical Constraints

- a. The optimum high speed route is a straight line. Costs may be prohibitive or the actual construction totally impractical if such a course is attempted. Geographical constraints that could be encountered could include very rough terrain requiring cuts, fills, bridges and tunnels. In such areas various alignments must be studied and the route selected may be a compromise of minimized construction costs

equated against train speed reductions and practical economics. As suggested in other sections, the use or partial use of existing rights-of-way often provides a satisfactory compromise when a totally new alignment proves too costly.

- b. Where the potential right-of-way passes or crosses waterways, other problems will surface. In crossing a waterway it must quickly be determined if it is navigable and what clearances are required by regulatory agencies. If the waterway is tidal, the extent of the tide and the flooding history must be studied to determine how close the new right-of-way can safely follow a shoreline.

1.3.2.3 Potential Routes

1.3.2.3.1 Railroad Rights-of-Way

In most cases there are two or more railroad rights-of-way between the cities of a given region, that could be considered. There are several factors which could make an existing railroad route unattractive for a high speed rail project.

- a. Numerous highway and street grade crossings that would be difficult to eliminate.
- b. Legal speed restrictions through populated areas.
- c. Sharp curvature that could not be modified to avoid speed reduction.
- d. Excessive grades and structures such as bridges and tunnels that might effect speed reduction.
- e. Difficult negotiations with property owners or political entities.
- f. Current and future freight traffic needs.
- g. Speed differential between freight and proposed passenger service.

1.3.2.3.2 Highway Rights-of-Way

Normally, a highway right-of-way would not be desirable for most of the reasons listed above and many highway alignment designs will not permit high speed alignments within the highway right-of-way. However, some locations exist where interstate highways in rural areas could share right-of-way with a high speed rail route, and with very few modifications, meet the criteria for high speed rail.

1.3.2.3.3 Utility Right-of-Way

Under some circumstances it might be feasible to utilize a utility right-of-way for a portion of a route.

1.3.2.3.4 New Route

It may be impractical and expensive to develop an entirely new route of 300 to 500 miles for a high speed project. In most cases, a combination of existing rights-of-way could be made by a judicious use of new connections.

1.3.2.4 Present and Future Airport Locations

Connections to present and future airport locations are desirable in order to effect a truly intermodal efficient passenger transportation system, since there are regions where it would not be economical to develop high speed rail for the long distance involved between metro areas.



1.3.2.5 Present and Future Rail Line Connections

Present and future rail line connections are desirable because it is desirable to maintain compatibility with existing infrastructure and equipment. In most cases, for practical operating reasons and for the convenience of the public, existing terminal facilities and access routes will need to be utilized in the large metro areas.

1.3.3 LOCATION OF ANCILLARY FACILITIES (1995)

Refer to [Chapter 6, Buildings and Support Facilities](#), and [Chapter 14, Yards and Terminals](#).

1.3.3.1 Stations

- a. The general station locations as to town, area, mile post location or other geographic area will largely be determined by the Demand for Services studies as outlined in [Article 1.2.2](#). Specific locations will involve considerations of the varied types of present and future transportation modes including commuter rail, rapid transit, bus, air, and auto. In the case of rail, across-platform transfer is the ideal arrangement where possible.
- b. Track geometry is another factor in specific station location. It is important that the station be located where the track is reasonably tangent with little or no grade. Bridge structures should also be avoided when locating stations, although stations may be located on viaducts. To minimize first cost and not over build for the future, provisions should be made for future ridership growth by providing room for additional train platforms, station structure, and parking.

1.3.3.2 Terminals

- a. The terminal location is generally constrained to the city or other area that is the terminus of the system. In a typical city it will often be necessary to locate the terminal along existing railroad rights-of-way. Securing a new route to the central city area, while often appearing to provide the best solution, typically will take years to acquire the property and complete the environmental impact study, and will be prohibitively expensive.
- b. Assuming that existing rights-of-way are to be used, the final station location should be located in or near the central business district, or very close to the location where the majority of riders find convenient. The main advantage of high speed rail will be maintained so that the center city to center city travel time is minimized with little or no transfers required.
- c. Terminal areas must be large enough to accommodate the following passenger and train equipment functions and Americans with Disabilities Act (ADA) requirements must be met:

1.3.3.2.1 Passenger Requirements

- Ticketing.
- Baggage and parcel checking.
- Restrooms.
- Phone and fax areas.
- Food and beverage service.

- Access to other modes of public and private transportation, lodging and tourist attractions.
- Lease retail areas, rental car areas, travel service, news stands and shops.
- Passenger waiting areas.
- Access to governmental, professional, financial, commercial and trade centers.
- Parking, including short-term, long-term, and drop-off areas.

1.3.3.2 Equipment Requirements

- Sufficient platform room for passenger boarding, equipment servicing and light duty maintenance.
- Fresh water fill facilities.
- Holding tank pump-out provisions.
- Three phase AC power stand by.
- Storage area for basic turn-around maintenance materials such as light bulbs, windows, printed circuit boards, seat parts, windshield wipers, etc.
- Turn-around cleaning.
- Space for train exterior car wash facilities at selected terminals.
- Secured commissary area for food and beverage restocking.
- Operation and Maintenance Departments offices.
- Locker and toilet facilities for operation and maintenance personnel.
- Future expansion.

1.3.3.3 Maintenance Facilities

1.3.3.3.1 Maintenance of Equipment

- a. The typical equipment maintenance yard and facilities will require a structure the size of which will depend on fleet size and how much work will be done at this location. The determination of the shop location will address the following considerations:
 - Locating near a terminal to minimize dead heading and to expedite return to service.
 - Undeveloped land in an industrial area with minimal residential neighbors.
 - Good highway access.
 - Adequate labor supply.



- b. The work tasks at such a shop will include the following with some specialized functions possibly contracted out:



- Federal Railroad Administration (FRA) scheduled locomotive inspections and service including daily attention such as sanding and fueling (if diesel locomotives are used) and pantograph shoe replacement.



- Scheduled car maintenance and overhaul.

- Unscheduled repairs.

- Heavy interior cleaning and refurbishment.

- Vehicle wheel truing on a scheduled basis or as needed.



- Truck overhaul.

- Heavy locomotive and car repair including damage.



- Storeroom system for new and used rebuild items such as traction motors, wheels, seating, electrical components, air conditioning, air brake, generators, motors, solid state components, draft gear, buffers, window assemblies, doors, etc.

- Offices, locker rooms, and classroom training facilities.

1.3.3.3.2 Maintenance-of-Way



A Maintenance-of-Way storage and maintenance facility consists of an open-yard in addition to limited secured buildings. The major storage and maintenance functions will include the following:

- Storage of on-road vehicles, high-rail vehicles.
- Track machinery maintenance equipment – storage and repair.
- Catenary on-rail inspection and service train.
- Maintenance-of-Way rail cars and ballast cars, etc.
- Storage of ties, turnout components, ballast, track fasteners, rail, catenary poles and related hardware.
- Catenary wire, insulators, and hardware.
- Power substation equipment such as transformers, circuit breakers, contractor assemblies, control equipment, cooling oil, section-break switching, relays, etc.
- Repairs and calibration of substation electrical components.
- Offices, locker rooms and training facilities.

1.3.4 SAFETY FACTORS (1995)

- a. There are two components to safety of a high speed rail operation:
 - (1) Hazards to the train.
 - (2) Hazards caused by the train.
- b. Both components must be considered and steps taken to mitigate or eliminate the risks in a particular corridor.

1.3.4.1 Grade Crossing Safety

- a. A major safety concern in any corridor evaluation is the presence of at grade vehicular crossings. The optimum route would provide grade separations. In some instances, this separation criteria may be impossible to obtain. The following could be implemented where grade crossings must exist:
 - Crossing occupancy detected by sensors and transmitted to train braking system.
 - Speed reductions imposed on trains where crossings exist.
 - A positive barrier system for vehicular traffic interfaced with the train as in Item 1.
 - Optimal design of approach roadway, site improvements and crossing warning devices.
- b. A high speed train can derail in addition to destroying a vehicle at a grade crossing. If the train must operate over a crossing at grade, a positive train or vehicle stop system is probably necessary. The alternative is lower operating speeds for the train.
- c. In locations where overhead separations exist, barriers can be installed to minimize the potential of vehicles falling or being thrown onto the track. Detectors that are activated when a vehicle falls from the structure can be connected to the signal system to alert the train crew to stop the train.
- d. The United States Department of Transportation has proposed the following guidelines for grade crossing safety for high speed lines:
 - (1) Speeds between 80 mph (128 kph) and 110 mph (176 kph)
 - All public and desirably all private crossings, where train speeds fall between 80 mph (128 kph) and 110 mph (176 kph), should either be closed, grade-separated, or equipped with special signing and active warning devices, which include gates and provide constant warning time.
 - Four-quadrant gates should be considered depending on risk factors.
 - Train-activated advance warning systems also should be considered, particularly where highway sight distance is restricted.
 - Traffic control devices at public crossings must conform with guidelines provided in the Manual on Uniform Traffic Control Devices (MUTCD).





(2) Speeds between 110 mph (176 kph) and 125 mph (200 kph)

- Those crossings over which trains are operated at speeds over 110 mph (176 kph) must be effectively blocked from vehicular entry. Based on currently accepted U.S. technology, this will require either closure or grade-separation.
- States wishing to demonstrate and test new technology, such as that now being used in other countries at crossings with train speeds between 110 mph (176 kph) and 125 mph (200 kph), must submit their proposals to the FRA for review. Following tests satisfactory to the FRA and FHWA, such installations may be considered at selected crossings in these corridors when justified.

(3) Speeds above 125 mph (200 kph)

- In territory where trains will be operating at speeds above 125 mph (200 kph), at-grade crossings will be prohibited.

(4) All crossings

- If train equipment not meeting current North American Standards is operated, more stringent grade crossing treatments may be required.

1.3.4.2 Operational Safety

1.3.4.2.1 Stations

Stations should be located and designed to minimize or eliminate the potential for injury to passengers. The following features are to be considered:

- Protection/warning for passengers on platforms where all high speed trains do not stop.
- Provisions that absolutely prevent passengers from encroaching on the train safety zone.
- At intermodal stations, positive design features to provide hazard-free transfer zones.

1.3.4.2.2 Right-of-Way Protection

- As with grade crossings, high speed rail right-of-way protection has two components.
 - Protecting trains from intruders.
 - Protecting intruders from trains.
- Methods for enhancing right-of-way protection include:
 - Fencing – entire rights-of-way or selected locations with various types of fence.
 - Providing grade-separated facilities such as pedestrian bridges, cattle or animal underpasses.
 - Raising or depressing the tracks to provide positive separation from other users.

1.3.5 ENVIRONMENTAL FACTORS (1995)

An investigation must be made to determine all the environmental impacts that would result from the development of a high speed rail line. These impacts may be positive or negative but must be given due consideration. For unavoidable adverse impacts mitigation measures must be determined. Compliance with all environmental standards will be required unless variances can be obtained. The following is a list of items to be examined.

- Land Use.
- Air Quality.
- Energy Conservation.
- Water Resources.
- Biological Systems – Wildlife and Vegetation, Endangered Species and Wetlands.
- Noise and Vibration.
- Electromagnetics.
- Aesthetic Qualities.
- Cultural – Historical and Archeological.
- Social Impacts.
- Beach and Shore Protection.
- Hazardous Materials.



SECTION 1.4 OPERATIONAL ANALYSIS



1.4.1 GENERAL (1995)



- a. The operational analysis of a new high speed rail system is entirely dependent on market driven parameter comparisons such as trip time versus projected ridership, growth potential versus train frequency, ticket costs versus alternate transportation costs, etc. These marketing projections will determine the basis for trip time goals and train frequencies required to capture the necessary travel market to justify investment in a high speed rail system. Ultimately, the required trip time and train frequencies will translate into the infrastructure improvements and capital cost requirements for a high speed system that meets the expectations of the customer. Therefore, the marketing projections and traffic modeling will be the determining factor in the overall planning of any high speed rail system.



- b. Once trip time goals, train frequency and capacity requirements are established, the operational analysis can be formulated with the following components: train operations, infrastructure, equipment, passenger handling, maintenance and maintenance facilities, stations and related facilities. This section addresses components of train operations including train schedules, train consist, operating speeds and equipment types; the other major operating issues are addressed in other sections of this chapter.



1.4.2 TRAIN SCHEDULES AND CONSISTS (1995)



- a. The foundation for train schedules must be built on market projections involving train frequencies, and stops to be served. These two parameters provide a basis for the number of trains, with their proposed stops and projected time of day for the stops, required to attract the future customer. This will allow for the development of a full train schedule. A train simulation model will assist in determining train schedule conflicts, infrastructure requirements to support the proposed schedule, the ability to plan for expanded service and the ability to predict operational bottlenecks. The train operations review must take into consideration such factors as: track outages for maintenance, train reliability and conflicts which arise when trains fail to maintain their schedule due to weather or other operational impacts, turn around time, and labor requirements.
- b. The train consist considerations are derived based on marketing projections for seating capacity, expansion projections, equipment operation and maintenance policies and passenger amenities. The areas to be explored are directly related to equipment types and are described in detail in [Article 1.4.4](#).

1.4.3 OPERATING SPEEDS (1995)

Trip time goals as established through market projections will determine both the ultimate top speed and average running speed of the rail system. This information combined with train frequencies will establish the fundamental speed related infrastructure and equipment parameters. Ultimately, the average running speed has the greatest impact on overall running time between station stops and therefore dictates the necessity to review in very close detail all physical characteristics of the property and system. The factors which must be considered when evaluating operating speeds include curve speeds (unbalance considerations), moveable bridges, road crossings, local town restrictions, signal system capabilities, train performance including acceleration, braking and top speed. Operating speed analysis must also take into consideration ride quality, passenger comfort, impacts on freight and other train operations, impacts on maintenance and capital costs, and maintainability.

1.4.4 TYPES OF EQUIPMENT (1995)

- a. Equipment considerations must be based on market requirements for top speed, average running speed, braking capability, seat and train capacity, physical characteristics of the right-of-way such as curves, unbalance requirements, tilt versus non-tilt technology, ride quality requirements, passenger amenities such as dining, snack, baggage handling, first class versus coach seating, electric versus non-electric power, unit train concept, maintenance requirements, maintenance facility requirements, turnaround servicing needs, pantograph spacing and performance (if electrically powered).
- b. The analysis must include overall equipment and operating policies involving trainset approach, where the equipment is operated in a predetermined consist of power cars and passenger cars which stay together as a unit and are not separated for maintenance or seat capacity increase, versus the traditional approach of varying train consists by adding or eliminating power cars and passenger cars based by individual train requirements. Both systems have advantages depending on the requirements of the operations, but require very different maintenance practices, maintenance facilities and operational considerations.
- c. In addition to the trainset approach other equipment system issues which must be evaluated include: articulated versus non-articulated trainsets, electric versus non-electric propulsion, tilt versus non-tilt system. Power considerations must include horsepower per ton requirements, single versus double heading of trains, cab car configurations, and multiple unit train systems.

1.4.5 OTHER OPERATING ISSUES (1995)

Station and yard layout, capacity requirements, passenger handling and ticketing, luggage handling, catering, reservation policy, cleaning and inspection staffing are operating issues that must be considered. Maintenance facility locations need also to be considered in planning the operation and may affect the fleet size. The fleet size requirement is determined by train rosters reflecting the service plan and including the daily inspection, maintenance and cleaning requirements, to which are added the other maintenance requirements, as well as some spares. Parameters such as flexible cleaning requirements at peak, or fast turn-around options have to be taken into account in that determination.

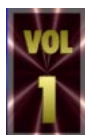


SECTION 1.5 FINANCIAL EVALUATION



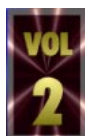
1.5.1 GENERAL (1995)

In order to determine the financial viability and feasibility of a high speed rail project, all elements of costs and revenues associated with the implementation of the project should be fully defined. All assumptions made in the preparation of the financial plan (such as interest rates, foreign exchange rates, inflation rates, etc.) should be fully described and substantiated. The plan should also identify in detail all sources and uses of capital funds needed for the project as well as sources and uses of operational funds on which the project's operational plan is based.



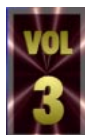
1.5.2 COST ANALYSIS (1995)

All elements of project costs should be fully identified including, but not limited to, preliminary study costs, engineering costs, capital infrastructure and equipment costs (both initial and ongoing), and financing costs (both debt and equity).



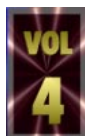
1.5.2.1 Preliminary Study Costs

Preliminary costs include costs that are incurred during initial feasibility studies that are required to arrive at a basic system definition. This will include the costs of preliminary ridership studies and preliminary alternative corridor and station location assessment studies.



1.5.2.2 Engineering Costs

All design and engineering costs associated with the high speed rail project should be fully established at an early stage of development of the plans. These will include environmental impact statement and mitigation costs.



1.5.2.3 Capital Costs

Initial and ongoing capital costs estimates should be prepared for the proposed system. The initial capital cost estimates will consist of all costs incurred to build the system up to the first day of revenue service including the preliminary engineering costs previously mentioned. The ongoing capital cost estimates will include all expected costs to be required for at least ten years from the start of operations. Elements of capital costs to be considered are:

- Environmental Impact Statement.
- Environmental Mitigation.
- Preliminary and Final Design and Engineering.
- Right-of-Way.
- Required Earthwork.
- Utilities Relocation.
- Track.
- Grade Separations.

- All Railroad Bridges.
- Roadway Bridges.
- Signalization.
- Electrification.
- Stations.
- Yards and Train Maintenance Facilities.
- Miscellaneous Costs.
- Construction Management.
- Rolling Stock or Train Sets Required.
- Design/Construction Contingency.
- Financing Costs.



1.5.3 OPERATING AND MAINTENANCE COSTS (1995)

Detailed estimates of annual operating and maintenance costs should be prepared for the full period of financial evaluation of the project. The methods used to develop each operating and maintenance cost element should be fully described. In addition to customary operating and maintenance cost elements such as labor, materials, vehicle maintenance, station maintenance, utilities, security, insurance and administrative costs, the estimate should include the costs of leasing the rolling stock, if applicable, or equipment replacement costs, and the costs of using any infrastructure owned by others.

1.5.3.1 Farebox Revenues

Based on the estimate of ridership and the anticipated fare structure, a detailed forecast of annual fare revenues should be prepared. The methods of producing the estimates shall be described in sufficient detail to allow the above projection to be checked or replicated.

1.5.3.2 Other Operations Revenue Streams

Forecasts shall be prepared of any additional sources of revenue anticipated from the proposed project. All assumptions, data and methods used to develop the forecasts should be specified. Such sources of revenue might include the receipts from advertising, station concessions, royalties, licenses, and from transporting parcels.

1.5.3.3 Real Estate and Supplemental Revenues

All amounts of real estate development and supplemental revenue sources that will be used to supplement system operations should be identified and substantiated.

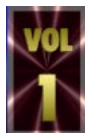
1.5.3.4 Public Sector Subsidies

Assumptions of any initial and/or long-term public sector operations subsidies should be identified and fully substantiated. The amounts and limitations of such subsidies and the years in which they will be required should be included.



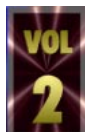
1.5.4 FINANCING CONSIDERATIONS AND ALTERNATIVES (1995)

The financing plan should cover construction of the high speed rail line as well as the operation of the system for a minimum period of twenty years. The financing plan should set forth in detail the proposed financing arrangement including all sources of funds that will be relied on for project financing.



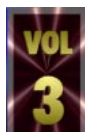
1.5.4.1 Debt Financing

All forms of debt-related financing should be investigated, including taxable bonds, tax-free bonds and bank loans. Amounts of debt-related financing should be identified along with the risks associated with it. The terms, maturity, and guarantees or other securities pledged to the repayment of such debt should be fully described. The costs associated with underwriting and issuing the debt instruments should be accounted for.



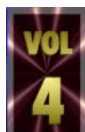
1.5.4.2 Equity

The amounts of private sector equity contributions should be identified and their sources fully described. All terms and conditions relating to these commitments should be identified and proof of the private sector ability to provide the equity commitment should be substantiated through the use of a bank's letter of credit or other appropriate banking instrument.



1.5.4.3 Government Participation

The level of public sector funding required for the project including those from federal, state and local governments should be fully identified. This contemplated public investment should be explained in detail including amounts and period over which it will be required. All legislative changes at all levels of government that will be necessary for securing those funds should be described.



1.5.4.4 Real Estate Development

All aspects of the high speed rail project capital financing plan which depend upon real estate development should be identified. Forecasts must be presented for project revenues anticipated from any land or property development, leasing or management activities to be undertaken in conjunction with the construction and operation of the high speed rail project, or from any "value capture" mechanisms developed as revenue sources for this project.

1.5.5 CASH FLOW, RETURN ON INVESTMENT AND OTHER FINANCIAL ANALYSIS (1995)

Considering all sources and uses of the capital and operations financing plans, a detailed total cash plan analysis should be prepared extending through the life of the project. Net Present Value and Internal Rate of Return calculations will be made. This analysis should be structured in a manner which will enable the testing of alternate assumptions on the financial feasibility of the project. Sensitivity analysis relating to various key assumptions such as interest rates, inflation rates, capital costs, and ridership estimates from Real Estate development should be conducted.

SECTION 1.6 INCREMENTAL HIGH-SPEED CORRIDORS (1998)

1.6.1 GENERAL (1998)

Sections 1.3 through 1.5 generally dealt with factors that must be considered in the evaluation of high-speed rail corridors allowing speeds in excess of 186 mph on new or upgraded existing rights-of-way. Sections 1.6 through 1.12 deal with Incremental High-Speed Rail (IHSR), which generally has been defined as upgraded intercity rail passenger service on existing railroad rights-of-way, most of which belong to freight railroads.

Proposed (goal) speeds for incremental high-speed rail range from 79 to 160 mph. Selection of Maximum Authorized Speed (MAS) for individual corridor depends on trip time goals between end (or intermediate) terminals, characteristics of the track structure and right-of-way, characteristics of rolling stock, existing Timetable Speeds, existence of cab signals, existence of grade crossings, and train control. Depending on the existing MAS for the corridor being evaluated, the range of potential incremental speeds includes: 79, 90, 110, 125, 135, 150, and 160 mph, or corridor-specific 5-mph increments.

1.6.2 EVALUATION OF INCREMENTAL HIGH-SPEED RAIL CORRIDORS (1998)

A variety of factors must be taken into consideration in the planning of Incremental High-Speed Rail Corridors; among them are:

1.6.2.1 Power Sources to be Used:

The power source for the train consists, which may be -

- (1) Fossil Fueled (non-electrified) - diesel-electric, turbine-electric, turbine -hydraulic, etc.
- (2) Electrified.

1.6.2.2 Equipment Consists:

A variety of train consists and operating characteristics may be assumed -

- (1) Variable consist (number of power units, coaches, and other cars may vary) versus Fixed Consist (number of power units, coaches, and other cars is fixed),
- (2) Tilt versus non-tilt equipment,
- (3) Current Amtrak Northeast Corridor (NEC) - operating up to 135 mph,
- (4) Planned NEC - to operate up to 150 mph,
- (5) Various foreign consists modified to satisfy North American requirements,
- (6) Locomotive versus distributed power (high versus low axle loads).



1.6.2.3 Identification of Existing and Proposed Corridor Rail Service Operators

Depending on the corridor, a variety of intercity, commuter, and freight rail services may be either presently operating on the corridor or be under consideration for future operations. All track owners and operators should be identified and included in the planning and corridor evaluation process.

The planning process should identify the market(s) to be served by proposed new rail services or enhancements to existing rail services. The demand for high-speed rail service is initially described in subsection 1.2.2. Incremental corridor planning requires that the planning process be expanded to include all existing or proposed rail service providers in or through the corridor.

1.6.2.3.1 Intercity - Existing or Proposed

A variety of intercity passenger trains may either presently be operated or proposed to be operated in or through a specific corridor. The planning process should identify existing service levels and those proposed to be operated at an agreed-upon planning horizon year -generally 15 to 20 years into the future.

1.6.2.3.1.1 Conventional - multi-stop trains

May include non-passenger equipment. Maximum speed of conventional trains is generally restricted by non-passenger equipment included in the train consist. Scheduled running times of conventional trains generally is significantly longer than published minimum trip times for “goal” or high-speed trains.

1.6.2.3.1.2 High-Speed - limited stop trains

Scheduled running times generally are equal to or slightly greater than published minimum trip times “goal” or high-speed trains, dependent upon number of stops.

1.6.2.3.2 Commuter

Depending on the length of the corridor one or more services may be operated within or into a specific corridor. The planning process should identify existing service levels and those proposed to be operated at an agreed-upon planning horizon year - generally 15 to 20 years into the future. Existing and proposed train service levels must be defined.

1.6.2.3.3 Freight

Depending on the length of the corridor one or more services may be operated within or into a specific corridor. The planning process should identify existing types of freight traffic, service levels and those proposed to be operated at an agreed-upon planning horizon year -generally 15 to 20 years into the future. Trains providing service to local industries also should be identified. Existing and proposed freight train service levels, including high and wide load requirements, must be defined.

1.6.3 EXISTING CORRIDOR CHARACTERISTICS (1998)

Site specific data on corridor physical and operating characteristics must be obtained. A variety of sources should be consulted to ensure that data are current.



1.6.3.1 Sources of Corridor Characteristic Data

Sources of information on corridor characteristics include:

- (1) Track Charts
- (2) Track geometry car data
- (3) Railroad engineering records, including but not limited to:
 - (a) Bridge Lists
 - 1 Information obtained should include - structure type, age, condition, maintenance and inspection records, expected capacity, remaining life, and traffic history, if available.
 - (b) Interlocking Lists
 - 1 Information obtained should include - size of turnouts, crossovers, year installed, and condition.
 - (c) Curve Lists
 - 1 Information obtained should include - length, degree of curvature, superelevation, speed through curve, transition (spiral) lengths.
 - (d) Grade Crossing lists
 - 1 Information obtained should include milepost, street/public highway intersected, type of protection, improvement plans, safety record and usage.
 - (e) Signal Plans
 - 1 Information obtained should include-interlocking plans, block spacing, block layouts, etc.
 - (f) Other data, including clearance information and operating restrictions.
- a. Mapping, including valuation plans and most recent aerial photography, USGS, utility, and geotechnical information.
- b. Recent land use studies and mapping.
- c. Timetables
- d. Interviews with engineering, operating, and planning personnel.
- e. Field Inspections
- f. Permanent and temporary slow orders.



1.6.3.2 Corridor Configuration



Corridor specific information on the present track configuration and alignment should be obtained. If electronic files containing a present map/chart are not available, a scale drawing showing the configuration should be developed. It should be used to show not only the present curves, tracks, and interlockings, but also the proposed configuration after the planning process is under way or has been completed. Components to be documented include:



- a. Main Tracks
- b. Sidings
- c. Interlockings/Control Points



- d. Yards
- e. Terminals
- f. Stations



- (1) Ownership
- (2) Air rights



- g. Maintenance Facilities
- h. Rail Crossings
- i. Rail Junctions
- j. At-grade highway crossings
 - (1) Public
 - (2) Private
- k. Bridges
 - (1) Undergrade
 - (2) Overhead
- l. Tunnels
 - (1) Clearances
 - (2) Cross sections
 - (3) Entrance and exit configuration

m. Right-of-Way Features

- (1) Drainage
- (2) Cuts and fills

n. Signal System

- (1) Type
- (2) Control locations

o. Electrification System

- (1) Substations
- (2) Catenary condition and type
- (3) Third rail condition and type

p. Existing or proposed utility easements.

1.6.3.3 Existing Conditions

a. Horizontal Curvature - by location

- (1) Simple, Compound, Reverse
- (2) Location
- (3) Hand
- (4) Degree
- (5) Length
 - 1 Transition Curves
 - 2 Body Curve
 - 3 Total Length
 - 4 Tangent length between curves
- (6) Vertical Curvature - by location
 - 1 Gradient
 - 2 Rate of change of gradient





(7) Rail Condition - by location

- 1 CWR/jointed
- 2 Installed - new, fit
- 3 Condition - age and weight
- 4 Planned Programs

(8) Crossovers/turnouts/crossings

- 1 Allowable speed by size
- 2 Interlocking Configurations
- 3 Number tracks
- 4 Number track ends
- 5 Number of crossovers, turnouts, including size, hand, definition of track no. to track no. connected, and condition/age

(9) Wayside crossovers, turnouts

- 1 Size
- 2 Hand
- 3 Track no. to Track no.
- 4 Condition/age
- 5 Location
- 6 Operation - Hand/remote
- 7 Electric/hand locked
- 8 Industry served
- 9 Status, active/inactive
- 10 Frequency of utilization.

(10) Clearances.