Chapter 10

Passenger, Transit & High Speed Rail

INTRODUCTION TO PASSENGER RAILWAY INFRASTRUCTURE

“Form ……follows function”
Louis Henri Sullivan, Architect, “Lippincott’s Magazine,” March 1896

10.1 Introduction

The above quotation, while originally written to describe the practice of architecture, nonetheless provides useful insight into the practice of passenger railway engineering. In particular, the concept concisely describes how fundamental differences in design can arise between a railway built for passenger service and one built for freight, as their functions (and hence their forms) may be radically different. However, while a passenger line and a freight-only line may look very different, the same engineering principles apply to each -- sound railway engineering is still sound railway engineering. The applications of these basic engineering principles will vary, however, to reflect the different functions each type of infrastructure must support.

This chapter presents an introduction to passenger rail infrastructure requirements. It does not dwell on basic railway engineering concepts. Instead, it expands upon the materials presented elsewhere in this *Practical Guide* as necessary to provide an overview of typical design principles, construction practices and maintenance considerations applied to passenger rail lines. The emphasis here is on the typical. The authors’ acknowledge that North American passenger experience is rich with exceptions to the "typical," and while a few exceptions have been noted herein, no attempt has been made to include them all. Instead, the intent is to provide a basic understanding of typical North American practice.

Those interested in learning more are invited to review Chapter 12 (Rail Transit) and Chapter 17 (High Speed Rail Systems) of AREMA's *Manual for Railway Engineering*. The reader is also referred to the *Track Design Handbook for Light Rail Transit*, published by the Transportation Research Board.

10.2 Passenger Rail Modes

Passenger rail operations in North America serve a wide variety of functions, from long distance intercity travel to daily commuter trips to local urban transit services. These operations encompass a diversity of vehicle types, operating speeds, right-of-way requirements and service frequencies. The characteristics of each type of operation are so different from one another that it is useful to think of each as a separate rail-based transport mode. For purposes of this chapter, the various types of passenger rail operations will be divided into six categories:

- High-Speed Rail ("HSR")
- Intercity
- Commuter Rail
- Rapid Transit ("RT")
- Light Rail Transit ("LRT")
- Streetcar and Vintage Trolley ("Streetcar")

These terms will be utilized throughout the chapter in describing the various rail modes and their infrastructure characteristics. People mover operations (such as found in airport terminals) are not addressed here, as these typically use proprietary vehicle and systems technologies, and are often based on rubber tire/concrete paving guideway systems.

10.3 Distinctions between Railway Operations and Transit Operations

The types of operations noted above can be separated into two major subgroups. High Speed Rail, Intercity and Commuter Rail may be considered "railway" operations while Rapid Transit, LRT and Streetcar may be considered "transit" operations. Characteristics, which distinguish between railway operations and transit operations, are discussed in general terms below.

Passenger railway operations are conducted over portions of the North American freight rail network, or on dedicated passenger lines that are contiguous to this network and which share compatible technical standards. (In the United States, Part 213.1 of the FRA regulations defines this as the "general system of railway transportation.") These systems generally utilize AREMA (or AREMA-compatible) technical standards for trackwork and AAR (or AAR-compatible) technical standards for vehicles. As such, these systems represent passenger adaptations of North American freight railway practice, and inter-operability with the freight network is maintained. Intercity and Commuter services are generally compatible with freight infrastructure practice, while HSR will employ more stringent standards for dedicated high-speed territories while retaining compatibility with freight infrastructure for conventional speed operations.

Transit operations are conducted on trackage that is dedicated to passenger service, not open to freight operations, and not part of the "general system of transportation." Technical standards are not based on interoperability with the North American rail network, but rather the stand-alone requirements of each operator. Trackwork and vehicle standards may be AREMA- and AAR-based, but more typically reflect transit practice with use of sharper track curvature and specialized track appliances, and lightweight vehicles with narrower wheels and smaller flanges. For the "traditional" systems (those built in the late 19th and early 20th centuries), track and wheel practice may still reflect the standards in effect at the time of construction. "New start" LRT systems (those built after approximately 1975) may utilize European transit track and wheel practices.

There is one hybrid type of operation that should be noted – LRT and freight services operating on shared trackage. In these systems, LRT and freight operations are typically "time separated," with LRT running during the day and freight running at night. Each service has exclusive use of the system during its designated operating period. In these systems, LRVs utilize wheel standards compatible with standard railway trackwork. Examples of such operations include San Diego and Baltimore.

- Curve Maintenance: The sharp curves found on transit properties can create the need for significant maintenance work. This work can involve gauging, fastener tightening and rail replacement. It is typically done with small equipment adapted to working in close confines.

- Special Track Appliances: As noted previously, transit properties make use of unique turnout designs, extensive check rail installations and other track features, which require maintenance. As these appliances typically require close control of dimensions (such as guard faces and back-to-back distances), significant attention is needed to keep them in adjustment.

- Maintenance Access: Physical access to conduct maintenance can be difficult, particularly for elevated structures and tunnels. Work processes and machinery must be adapted to deal with the available access and working space.

- On some properties, alignment imperfections in small bore tunnels caused by construction tolerances translate to deliberate imperfections in track geometry necessary to keep track centered within the tunnel.

10.10 Special Topics Associated with Passenger Railway Operations

10.10.1 Passenger Railway Line Capacity

Unlike highways, which measure unlinked trips over individual route segments, rail line capacity fundamentally must be considered as a network evaluation. The type of train service, where it begins, and where it is destined are equally important components, along with the infrastructure itself. Whether it is through or local operations, routine maintenance or seasonal impacts, operators must consider events that have the potential for creating cascading effects on a given route's performance, even though they may happen many miles away.

Capacity analysis begins with an evaluation of the physical route. The length of the line, terrain it operates through (curvature, gradient, etc.), number of tracks and type of train control exercised over the line all set the stage for determining some of the most basic components of line capacity. Train performance characteristics in terms of maximum speeds, acceleration (HP/ton) and deceleration rates are critical to determining throughput rates for unopposed trains. Equally as critical is the mix of train types, as there will be pronounced differences in end-point transit times when comparing passenger, intermodal, manifest and unit freight train types. Distance between terminals, capacities of the terminals, local switching enroute, performance variability and day-of-week variability are key factors to be considered.

Where passenger trains operate over a freight route, the difference in running times becomes even sharper. Besides the criteria typically considered for freight service, the number of station stops, dwell times at each station, and distances between stations must be considered. Passenger trains typically are permitted to operate at higher maximum speeds and through curves at higher speeds by employing greater levels of cant deficiency when compared to freight trains. The effect of both is to further reduce transit times. Terminal operations must also be factored into a line capacity analysis, as trains typically follow a different route or multiple routes at slower overall speeds compared to operations on the main line.

If every train operated in the same direction, at precisely the same speed and assuming a relatively sophisticated method of controlling train movements, line capacity over a single track would be very high. If this same group of trains were split evenly so one half operated in the opposite direction and uniform length passing sidings were evenly distributed, line capacity would drop proportionate to siding distance and to reflect the time required to reset routes through interlockings and for trains to accelerate and decelerate for siding entry and exit. Overall capacity would remain relatively high, however.

Neither of the above situations occurs often in real life. Geography, community development, and the markets served can, and do, greatly affect the design and configuration of a rail line. Much more typical would be sidings of varying lengths, with unequal distances between them. Ruling grades frequently bring average speeds of freight trains down to very slow speeds or require adding helper locomotives to negotiate grades. Dispatchers must carefully plan meets between opposing trains of varying types around the physical infrastructure capable of accommodating them. Intermodal and passenger trains will “overtake” slower trains along the route and dispatchers must stage passes between trains running in the same direction in order to allow the faster trains to proceed without delay. Locals and work trains occupy main line tracks for extended periods of time while performing their duties. The net effect of all of these operations is to reduce rail line capacity.

Rail line capacity is not easily determined. In addition to differences in the types and numbers of trains, their speeds and their overall reliability, capacity is constrained by the number of tracks, interlockings and their spacing, types of train control and signal systems in place, FRA track class, moveable bridges, permanent slow orders, grade crossings, etc. Each of these elements may contribute to, or reduce, the handling capability of a route.

Undertaking an operations simulation of the line is one accepted method to determine line capacity. This is generally performed through the development of representative operating plans, for both existing and future scenarios, and testing them against the available fixed plant. Iterative variations of plans can lead to identification of optimal operating plans that maximize use of the line. Most simulations are now performed through use of computer software programs, the more sophisticated of which accurately emulate actual operating conditions. These programs also provide a powerful set of decision-making tools to help determine infrastructure improvements. They may be used to identify chokepoints on a line that constrain growth, to adjust fixed plant investment in response to traffic changes, or to assist in programming maintenance activities. Computer simulation technology continues to advance, reducing set up and evaluation procedures, and making its use progressively more valuable in a quickly changing environment.

North American railways already operate among the most efficient rail systems in the world (in terms of ton-miles per route-mile). This status has been achieved by a variety of means to balance fixed-plant investment against operating requirements. As projected rail traffic levels continue to grow, greater use of the existing infrastructure will place ever-higher emphasis on maximizing its use. Understanding and being able to utilize each line's capacity will be key to success.

10.10.2 The Impact of Superelevation (Or Cant Deficiency and Why It's Important)

Chapter 3 introduced the concept of unbalance or underbalance in operation through horizontal curves. In passenger rail terminology, this same concept is generally referred to as "cant deficiency." The term is drawn from British and European practice where superelevation is referred to as "cant" and the term "cant deficiency" describes the circumstance where a vehicle operates through a curve with insufficient cant to achieve equilibrium.

Superelevation (banking or track cant) is a necessary ingredient for safe and comfortable curve negotiation. Superelevation is used to counteract the effects of centripetal acceleration (centrifugal force) on the vehicle and the occupants. The amount the outer rail is elevated is determined by the sharpness of the curve and the speed the vehicles operate through it.

Some definitions are in order:

- Balance Speed: The speed at which the combination of curvature and superelevation exactly balance the centripetal acceleration and the resultant force vector is normal to the track plane.