FINAL REPORT
GUIDELINES FOR ENHANCING INTERMODAL CONNECTIONS AT FLORIDA TRANSIT STATIONS

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Transit Office

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Design Guidelines for Florida Transit Stations

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Increasing population growth is continually challenging transportation officials to institute measures to meet travel needs at a desirable level of service. Local transit and intermodal travel provide an alternative to the personal automobile mode of transportation, hence assisting in reducing congestion. To encourage transit ridership, transit amenities and facilities should be designed to encompass features which will enhance transit patronage by accommodating or easing the shift from one mode of travel to the next. The long-term success of transit projects is closely linked to creating connectivity to all modes in station areas. Of high importance is a station area design. Properly planned transit stations encourage the use of all modes of transportation including pedestrian and bicycle connectivity. Additionally, station area principles that promote the use of public transportation and are compatible with private automobiles are imperative to successful multimodal services.

The safe and efficient movement of passengers to and from the train to the bus and other modes of transportation is also vital to the success of other transportation services. Fewer passenger vehicles on highways will result in less traffic congestion, and less carbon emissions, thus creating healthier more livable communities. This can be accomplished by identifying best practices in a station area facility design which focuses on safe and efficient mode shifts.

**Purpose and scope**

These guidelines provide a comprehensive reference for planning and designing transit station areas. Intended project applications include Bus Rapid Transit (BRT) and rail (light, heavy, and commuter) stations which also include accommodations for bus transit, bicycle, and pedestrian modes. Guidance for designing features necessary for the safe and efficient transfer between different modes of transportation at station areas is also addressed. These guidelines
provide considerations for special populations including the disabled consistent with the Americans with Disability Act (ADA) and the elderly.

**Audience**

These design guidelines are available to the Florida Department of Transportation (FDOT), transit agencies, and other government agencies in evaluating station area plans for transit projects. These guidelines will be used by a wide range of transit officials including design engineers, land-use planners, and transportation planners from the public and private sectors in planning and designing transit station areas that meet intermodal standards with amenities necessary to encourage non-motorized modes of transportation. For guidelines on bus facilities at transit stations, the user is referred to the Florida Department of Transportation Accessing Transit Version II. Guidelines on providing specific facilities for pedestrians, bicycles, and Park-and-Ride could be obtained from different state and nationally recognized guidebooks.

**Organization of guidebook**

These guidelines provide a combination of balanced narrative, graphics and illustrations in an attempt to communicate the complex intermodal design issues at transit stations in a concise and direct manner which is useful for a range of stakeholders. The following is a brief description of each chapter of this guide:

**Chapter 1** provides an introduction to the guidebook and describes the process that was followed in developing design guidelines for transit stations.

**Chapter 2** presents station platform design principles. Design features recommended for safe and efficient loading and alighting of passengers at the platform are discussed.

**Chapter 3** contains valuable information regarding transit signing and wayfinding features. Passenger wayfinding elements from station entry points to transit boarding are addressed in this chapter.
Chapter 4 documents green engineering initiatives. Several design initiatives ranging from using recycled materials to adopting energy efficient design are discussed.

Chapter 5 offers transit station prototypes. These prototypes cover basic design elements necessary for intermodal connectivity at transit stations. The prototypes are based on best practices and models from existing and planned transit stations in Florida and beyond.
 CHAPTER 1 INTRODUCTION

Accessibility of transit facilities is paramount to the provision of a comprehensive mobility system. The importance is further heightened by the Federal Energy Independence and Security Act of 2007 which urges state and local governments to consider policies designed to accommodate all users including motorists, pedestrians, cyclists, transit riders, and people of all ages and abilities in order to serve all surface transportation users by creating a more interconnected and intermodal system. The Act further emphasizes the use of environmentally friendly options such as public transportation, walking, and bicycling. As the primary interface for passengers, transit stations provide premium services such as light rail and Bus Rapid Transit (BRT). Promoting station area facility designs which focus on seamless movement of passengers changing modes of transportation at the station would help to accomplish a safe and efficient movement of passengers arriving and leaving the station area.

Different local and state agencies have established their own design guidelines for station facility design. Although much has been published on design guidelines for transit facilities (rail and BRT systems), no guidelines have been prepared with an exclusive focus on intermodal connectivity. In addition, the existing guidelines have more general applications with little guidance for transit station intermodal facilities. These guidelines emphasize the additional features necessary to enhance shifts from one mode of travel to another within a transit station. Figure 1.1 shows a sketch of a typical transit station.
Design guidance developing process

To begin the process of enhancing intermodal activity, planners should attempt to identify the various arrival modes, intermodal movements, user groups and user group mobility needs before designing a station to address all intermodal movements. Figure 1.2 depicts a graphical presentation of a recommended process to follow when designing an intermodal transit facility. The proposed process is discussed in the following sections in detail.
1. Possible arrival modes of transportation

Passengers may arrive at a transit station by a variety of means. These arrival types are illustrated in Figure 1.3. The means include arriving by bus, shuttle, taxi, and paratransit services as well as personal automobile, bicycling, walking, or other transit modes. Station design should include features necessary for providing convenient access to the station by all common modes of transportation. Features such as bus bays for buses and shuttles, kiss-and-ride for drop-off vehicles and paratransit vehicles, Park-and-Ride for private automobiles, and bicycle racks for cyclists are normally provided for accessibility of the aforementioned arrival modes. Typically, the last mode of transportation before boarding the transit vehicle is walking. The design process should ensure seamless and safe movements of pedestrians as they interact with other modes at the station.
2. Identify possible intermodal movements at the station

Common intermodal movements are graphically summarized in Figure 1.3. Typically, the last mode of transportation before boarding the transit vehicle is walking. A pedestrian is any person who is afoot or who is using a wheelchair or a means of conveyance propelled by human power other than bicycle. Passengers arriving at the station by modes of transportation other than walking will change modes to the pedestrian mode before accessing a transit vehicle. Passengers arriving at the station via buses will use a sidewalk/pathway to walk towards the platform after unloading from buses. On the other hand, passengers arriving by private automobiles will have to
use crosswalks to cross circulation roads at the Park-and-Ride facility before reaching the sidewalk on the way to the platform. Therefore, safe and convenient pedestrian access between and across all modes is vital to ensure intermodal connectivity.

3. Identify user groups of different modes of transportation

Access to transit facilities can be a sensitive issue. Transit users range from able bodied people who are fit and agile to physically challenged users who suffer from different disabilities. The Universal Design Handbook [1] categorizes people with limited mobility in eight levels. Level 1 has fit and agile people, those who can run and jump, leap up stairs, and carry loads of heavy baggage. Level 2 includes the generality of normal adult able-bodied people who can walk, with flights of stairs not troubling them. Level 3 consists of people who may not be considered as disabled but are of small size/stature, hence have limited mobility compared to people with normal size. Level 4 includes older people who although perhaps need assistance of a cane or walker, are not perceived as having a disability. By comparison with younger adult people, the elderly are commonly prone to limited access caused by steep steps or stairs without handrails. Also in level 4 are people with infants in strollers. Ambulant people with disabilities are in level 5. People in level 6 are independent wheelchair users while level 7 includes people with disabilities who drive electric scooters and those who use wheelchairs who need another person to facilitate their mobility. The top level, level 8, consists of wheelchair users who need two people to help them when they go out.

Special accommodation is needed for people with vision impairments. Vision impairment spans a continuum, from total blindness at one extreme to partial sight, or low vision, at the other. Other types of impairments include hearing, cognitive, and language impairments. Passengers with more than one type of impairment are faced with even more difficulties in using transit station facilities and amenities. Table 1.1 summarizes special features that might be needed to facilitate usage of transit station by passengers with different impairments.
4. Identify issues associated with each transit user group

Design guidelines have to address key accessibility issues associated with each transit user group. Identification of issues associated with each type of impairment is necessary to ensure that stations are designed to accommodate all types of passengers. Table 1.2 summarizes some common station features and issues faced by each user group. These features should be considered in the station design, where possible.

5. Provide features needed for transit access for each user group

Table 1.1: Special features for different user groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Impairment</th>
<th>Physical aid(s) used</th>
<th>Features needed for station accessibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobility 1</td>
<td>Physically fit</td>
<td>N/A</td>
<td>Loading/unloading area</td>
</tr>
<tr>
<td>Mobility 2</td>
<td>No use of legs</td>
<td>Wheelchairs, scooters</td>
<td>Clear path, loading/unloading area</td>
</tr>
<tr>
<td>Mobility 3</td>
<td>Limited strength, endurance, dexterity, balance,</td>
<td>Wheelchairs, scooters, canes, crutches, walkers, seating, leaning posts, assistants</td>
<td>Clear Path, loading/unloading area</td>
</tr>
<tr>
<td>Visual 1</td>
<td>Total blindness</td>
<td>Canes, dogs, assistants</td>
<td>Auditory, tactile surface, consistency</td>
</tr>
<tr>
<td>Visual 2</td>
<td>Partial blindness</td>
<td>Canes, dogs, assistants</td>
<td>Auditory, tactile surface, consistency, color, contrast, lighting</td>
</tr>
<tr>
<td>Hearing</td>
<td>Deafness</td>
<td>Hearing aids</td>
<td>Visual displays</td>
</tr>
<tr>
<td>Cognitive</td>
<td>Impaired development, language, comprehension</td>
<td>N/A</td>
<td>Simple language, consistency, symbols</td>
</tr>
<tr>
<td>Language illiterate</td>
<td>Impaired reading, speaking, lack of English</td>
<td>N/A</td>
<td>Simple language, symbols</td>
</tr>
</tbody>
</table>
### Table 1.2: Specific Issues by user group and specific station features

<table>
<thead>
<tr>
<th>Feature/Group</th>
<th>Mobility 1</th>
<th>Mobility 2 &amp; 3</th>
<th>Visual 1 &amp; 2</th>
<th>Hearing</th>
<th>Cognitive</th>
<th>Language illiterate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Park-and-ride</strong></td>
<td>Distance to the platform</td>
<td>Disabled parking</td>
<td>Distance to the platform</td>
<td>Distance to the platform</td>
<td>Distance to the platform</td>
<td>Distance to the platform</td>
</tr>
<tr>
<td><strong>Drop-and-Ride</strong></td>
<td>N/A</td>
<td>Distance to the platform</td>
<td>Connection path to platform</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Bus terminal</strong></td>
<td>Crossing location</td>
<td>Gap between platform and bus door</td>
<td>Crossing location</td>
<td>Crossing location</td>
<td>Crossing location</td>
<td>Crossing location</td>
</tr>
<tr>
<td><strong>Bicycle racks</strong></td>
<td>Location</td>
<td>N/A</td>
<td>Location</td>
<td>Location</td>
<td>Location</td>
<td></td>
</tr>
<tr>
<td><strong>Sidewalk</strong></td>
<td>Width</td>
<td>Barriers</td>
<td>Barriers</td>
<td>Width</td>
<td>Connectivity</td>
<td>Connectivity</td>
</tr>
<tr>
<td><strong>Walkway</strong></td>
<td>Width</td>
<td>Obstructions</td>
<td>Obstruction on the path</td>
<td>Width</td>
<td>Connectivity</td>
<td>Connectivity</td>
</tr>
<tr>
<td><strong>Ramp</strong></td>
<td>Width</td>
<td>Slope</td>
<td>Width</td>
<td>Slope</td>
<td>Width</td>
<td>Slip surface</td>
</tr>
<tr>
<td><strong>Stairs</strong></td>
<td>Treads</td>
<td>N/A</td>
<td>No handrail</td>
<td>Treads</td>
<td>Tactile strip</td>
<td>Tactile strip</td>
</tr>
<tr>
<td><strong>Elevators</strong></td>
<td>Cab size</td>
<td>Cab size</td>
<td>Cab size</td>
<td>Cab size</td>
<td>Cab size</td>
<td></td>
</tr>
<tr>
<td><strong>Signage</strong></td>
<td>Inconsistency</td>
<td>Inconsistency</td>
<td>Not able to read conventional signs</td>
<td>Directions</td>
<td>Direction</td>
<td></td>
</tr>
<tr>
<td><strong>Ticket booth</strong></td>
<td>Difficult to use</td>
<td>Difficult to use</td>
<td>Difficult to use</td>
<td>Difficult to use</td>
<td>Difficult to use</td>
<td></td>
</tr>
<tr>
<td><strong>Platform</strong></td>
<td>N/A</td>
<td>Gap between platform and vehicle’s door</td>
<td>No warning strip</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td><strong>Bench</strong></td>
<td>Few benches if waiting time is &gt;15 minutes</td>
<td>Few benches if waiting time is &gt;15 minutes</td>
<td>No indication of bench</td>
<td>Few benches if waiting time is &gt;15 minutes</td>
<td>Few benches if waiting time is &gt;15 minutes</td>
<td></td>
</tr>
<tr>
<td><strong>Shelter</strong></td>
<td>No leaning rail</td>
<td>No area for wheelchair/scooter</td>
<td>No indication of shelter</td>
<td>No leaning rail</td>
<td>No leaning rail</td>
<td></td>
</tr>
</tbody>
</table>

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### Table 1.3: Provisions for specific station features

<table>
<thead>
<tr>
<th>Feature/Group</th>
<th>Mobility 1</th>
<th>Mobility 2 &amp; 3</th>
<th>Visual 1 &amp; 2</th>
<th>Hearing</th>
<th>Cognitive</th>
<th>Language illiterate</th>
</tr>
</thead>
</table>
| Park-and-Ride       | Minimize distance to the platform  
Delineated raised crossing | Provide disabled parking.  
Minimize distance to the platform  
Delineated raised crossing | Minimize distance to the platform  
Delineated raised crossing | Minimize distance to the platform  
Delineated raised Crossing | Minimize distance to the platform  
Delineated raised Crossing | Minimize distance to the platform  
Delineated raised Crossing |
| Drop-and-Ride       | N/A  
Provide connection to platform | N/A  
Provide connection to platform | N/A  
Provide connection to platform | N/A  
Provide connection to platform | N/A  
Provide connection to platform | N/A  
Provide connection to platform |
| Bus terminal        | Locate crossing in front/back of the bus  
Minimize gap between platform and bus door | Locate crossing at the back of the bus  
Minimize gap between platform and bus door | Locate crossing at the back of the bus  
Minimize gap between platform and bus door | Locate crossing at the back of the bus | Locate crossing at the back of the bus | Locate crossing at the back of the bus |
| Bicycle racks       | Near shelter  
N/A  
Provide curb ramp  
Maintain connectivity | N/A  
Provide curb ramp  
Maintain connectivity | N/A  
Provide curb ramp  
Maintain connectivity | N/A  
Provide curb ramp  
Maintain connectivity | N/A  
Provide curb ramp  
Maintain connectivity | N/A  
Provide curb ramp  
Maintain connectivity |
| Sidewalk            | Provide enough width  
Clear path  
Provide curb ramp  
Maintain connectivity | Clear path  
Provide够 enough width  
Provide tactile strip before crossing | Provide enough width  
Clear path  
Provide enough width  
Provide tactile strip before crossing | Provide enough width  
Clear path  
Provide enough width  
Provide tactile strip before crossing | Provide enough width  
Clear path  
Provide enough width  
Provide tactile strip before crossing | Provide enough width  
Clear path  
Provide enough width  
Provide tactile strip before crossing |
| Walkway             | Provide enough width  
Connectivity | Clear path  
Provide enough width  
Provide curb ramp  
Maintain connectivity | Clear path  
Provide enough width  
Tactile before crossing  
Provide curb ramp  
Maintain connectivity | Clear path  
Provide enough width  
Tactile before crossing  
Provide curb ramp  
Maintain connectivity | Clear path  
Provide enough width  
Tactile before crossing  
Provide curb ramp  
Maintain connectivity | Clear path  
Provide enough width  
Tactile before crossing  
Provide curb ramp  
Maintain connectivity |
| Ramp                | Provide enough width  
Non-slip or glare surface  
Continuous railing | Provide enough width  
Non-slip or glare surface  
Slope | Provide enough width  
Non-slip or glare surface  
Slope | Provide enough width  
Non-slip or glare surface  
Slope | Provide enough width  
Non-slip or glare surface  
Slope | Provide enough width  
Non-slip or glare surface  
Slope |
| Stairs              | Provide handrail  
Provide wide treads  
Tactile on top step of stair approach  
N/A | Provide handrail  
Provide wide treads  
Tactile on top step of stair approach  
N/A | Provide handrail  
Provide wide treads  
Tactile on top step of stair approach  
N/A | Provide handrail  
Provide wide treads  
Tactile on top step of stair approach  
N/A | Provide handrail  
Provide wide treads  
Tactile on top step of stair approach  
N/A | Provide handrail  
Provide wide treads  
Tactile on top step of stair approach  
N/A |
| Elevators           | Enough turn around room to all elevator cabs  
Floor announcement | Enough turn around room for elevator cabs  
Floor announcement | Enough turn around room for elevator cabs  
Floor announcement | Enough turn around room for elevator cabs  
Floor announcement | Enough turn around room for elevator cabs  
Floor announcement | Enough turn around room for elevator cabs  
Floor announcement |
| Signage             | Maintain consistency  
Provide eye-level signage | Tactile labels  
Appropriate font size  
Contrasting signage | Visual display directions | Symbol direction  
Contrasting signage  
Appropriate font size | Symbol direction  
Contrasting signage  
Appropriate font size | Symbol direction |
| Ticket booth        | Locate in the immediate area  
Provide enough front or side reach | Audible instructions and tactile labels  
Locate in the immediate area  
Provide enough front or side reach | Audible instructions and tactile labels  
Locate in the immediate area  
Provide enough front or side reach | Audible instructions and tactile labels  
Locate in the immediate area  
Provide enough front or side reach | Audible instructions and tactile labels  
Locate in the immediate area  
Provide enough front or side reach | Audible instructions and tactile labels  
Locate in the immediate area  
Provide enough front or side reach |
| Platform            | N/A  
Wheelchair pad  
Minimize gap between Platform and vehicle’s door | Provide a warning strip  
N/A  
Wheelchair pad  
Minimize gap between Platform and vehicle’s door | Provide a warning strip  
N/A  
Wheelchair pad  
Minimize gap between Platform and vehicle’s door | Provide a warning strip  
N/A  
Wheelchair pad  
Minimize gap between Platform and vehicle’s door | Provide a warning strip  
N/A  
Wheelchair pad  
Minimize gap between Platform and vehicle’s door | Provide a warning strip |
| Bench               | Provide enough benches when waiting time is >15 min  
Provide enough seats for non-wheelchair users | Provide guidance to benches  
Provide enough benches when waiting time is >15 min  
Provide enough seats for non-wheelchair users | Provide guidance to benches  
Provide enough benches when waiting time is >15 min  
Provide enough seats for non-wheelchair users | Provide guidance to benches  
Provide enough benches when waiting time is >15 min  
Provide enough seats for non-wheelchair users | Provide guidance to benches  
Provide enough benches when waiting time is >15 min  
Provide enough seats for non-wheelchair users | Provide guidance to benches  
Provide enough benches when waiting time is >15 min  
Provide enough seats for non-wheelchair users |
| Shelter             | Provide leaning rail  
Provide area for wheelchair/scooter | Provide guidance to shelter  
Provide leaning rail  
Provide area for wheelchair/scooter | Provide guidance to shelter  
Provide leaning rail  
Provide area for wheelchair/scooter | Provide guidance to shelter  
Provide leaning rail  
Provide area for wheelchair/scooter | Provide guidance to shelter  
Provide leaning rail  
Provide area for wheelchair/scooter | Provide guidance to shelter  
Provide leaning rail  
Provide area for wheelchair/scooter |
6. Identify interconnectivity points and issues that might be faced by each group

Transit stations serve as an interface between the transit system and other modes of transportation. The stations are characterized by interaction between various modes of transportation. If not properly designed, interaction between different modes can result in conflicts between modes which might in turn discourage patrons from using the transit system. A station designed with interconnectivity in mind provides a seamless, safe, and convenient movement of patrons as they access and egress the station. Examples of station design which poses interconnectivity issues include 1) a design for which bus stops, Park-and-Ride, and other facilities are located across a busy street; 2) inefficient Park-and-Ride configuration; 3) improper wayfinding sign placement and design; 4) designs which do not serve all types of impairments; and 5) inefficient circulation of traffic at the station. Identification of these and many other issues in the process of developing design criteria and guidelines would help eliminate connectivity issues hence enhancing safety, efficiency, and the convenience of patrons as they enter and leave the stations.

7. Determination of the minimum design guidelines

Station area design must address all accessibility issues faced by each user group as they access and egress stations. There are numerous authoritative design guidelines published by different entities ranging from federal agencies to local authorities. Minimum criteria and recommended practice can be found in these guidelines. In addition to the existing design guidelines, the process of developing transit station design guidelines should utilize the lessons learned and best practices from past experiences. Equally important, the process should involve engineering judgment based on the principles of science and engineering.

7a. Consult existing guidelines for specific features

Several federal agencies have established guidelines that are often referenced in the
design of transit stations. One of the most popular guidelines used is the *Americans with Disabilities Act Accessibility Guidelines (ADAAG) for Buildings and Facilities* [2]. This report contains technical requirements for accessibility to buildings and facilities under the Americans with Disabilities Act (ADA) of 1990. The ADA guidelines are applied in the design, construction, and alteration of facilities. A handbook entitled *Accessibility Handbook for Transit Facilities* [3] was prepared by the Federal Transit Administration (FTA) in 1992. This handbook provides detailed information to help transit designers and planners to construct and renovate transit facilities so that they are accessible to individuals with disabilities of all types including mobility impairments requiring the use of a wheelchair. This handbook also provides facility accessibility checklists to facilitate compliance with the disabilities act.

The American Association of State Highway and Transportation Officials (AASHTO) has published several guidelines that are used to determine minimum design criteria for intermodal and other highway facilities. AASHTO publications include the *AASHTO Guide for Park-and-Ride Facilities* [4] and *AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities* [5]. The *AASHTO Guide for Park-and-Ride Facilities* provides necessary information for the design of parking facilities including minimum criteria necessary for circulation and accessibility. The *AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities* provides guidance on planning, designing, and operations of pedestrian facilities along highways and streets. The manual’s primary focus is to provide guidance on how pedestrians can best be accommodated on public right-of-way. It also provides minimum design criteria for accessibility of pedestrian facilities.

The *Highway Capacity Manual (HCM)* [6] and its companion the *Transit Capacity and Quality of Service Manual (TCQSM)* [7], both published by the Transportation Research Board, are another set of nationally recognized manuals. While the HCM was specifically prepared to provide methods for evaluating quality of service for roadway, pedestrian, and bicycle facilities, the TCQSM is aimed at assisting
transportation practitioners to have a consistent set of techniques for evaluating the required capacity and quality of transit services, facilities, and systems.

The research sponsored by the Transit Cooperative Research Program (TCRP) produced the Guidelines for Transit Facility Signing and Graphics [8], also known as TCRP Report 12. The report describes the use of signs and symbols that provide for the safe and efficient movement of passengers to and through transit facilities. The general format of the report was developed to lead transit providers through the entire process from wayfinding design to actual installation of the signs. Several versions of common symbols in English, Spanish, French, German, Italian, Korean, and Chinese are listed in the report. The report further discusses the ability of symbols to communicate meaning in various languages.

Apart from the federal agencies, nationwide transit providers such as Amtrak and Greyhound have established guidelines for the design of their station facilities. Amtrak which stands for “American” and “track” is operated by the National Railroad Passenger Corporation and provides inter-city passenger transportation service. The Amtrak Station Manual [9] has standards and guidelines for pedestrian access and circulation, vehicular access and circulation, and train information signage, among other station features. Some stations have connections to inter-city bus transportation. Greyhound Lines Inc. is the largest provider of inter-city bus transportation across North America. Greyhound guidelines [10], also known as sizing documents, provide guidance on geometric features necessary to accommodate Greyhound buses, passenger accessibility, and bus terminal survey forms to ensure compliance to design standards. As Florida embarks on expanding intercity rail travel with Amtrak, these will prove to be useful guidelines.

7b. Use engineering knowledge

The use of established guidelines and best practices should be complimented by sound engineering knowledge. One example where the engineering knowledge could be used is on setting the maximum walking distance to the parking lot. For example, according to O’Sullivan and Morrall [12], the
general walking distance guideline is that the person will walk a maximum of about 5 minutes to reach the bus stop at light-rail transit stations. An average pedestrian walking speed of 4 feet per second is typically used for designing roadway facilities [6]. A walking speed of 3 feet per second is commonly used for the elderly population. Using engineering knowledge and equations of motion these recommended design speeds with the general guideline of 5 minutes would result in a maximum walking distance of about 900 to 1200 feet. Engineering knowledge of traffic conflicts and human factors in engineering design could also be used in providing guidelines of transit station facilities.

7c. Employ best practices and lessons learned

Best practices and lessons learned have been documented by numerous studies. While best practices would identify recommended practices, lessons learned would provide information on practices that need to be avoided based on past experience. For example, a study that was performed by Spillar [11] recommended that it is important for the loading bay to be perpendicular to the parking lot to motivate good usage of available walkways and prevent the tendency of pedestrians to take shortcuts. The study that was performed to establish the Guide for the Design of Park-and-Ride Facilities [4] recommended a raised pedestrian path above the driving surface, because apart from delineating a pedestrian crosswalk, it also acts as a speed hump.

8. Provide minimum design guidelines for each specific feature

All specific features to ease mobility between modes should be identified in one overall list. Design guidelines can be presented in variable formats. The Design Handbook for Florida Bus Passenger Facilities [13], for example, presents design guidelines by describing three design elements which include 1) purpose; 2) location factors; and 3) design factors. In contrast, the Federal Highway Administration (FHWA) Pedestrian Road Safety Audit Guidelines and Prompt Lists [14] use prompt lists to provide guidance on the pedestrian road safety audit process.
For each particular prompt, a detailed description of each prompt is given followed by the road safety audit example. The detailed description of the prompts includes 1) problem description to include situations where issues arise and potential specific consequences; 2) special considerations for the road safety audit team; and 3) photographs illustrating the problem. Other agencies such as the Easter Seals Project Action [15] uses compliance checklist to ensure adherence to the design minimum criteria. Conversely, other guidelines such as the British Columbia Municipal Systems Program Design Guidelines for Accessible Bus Stops [16] lists design guidelines in point format. The British Columbia guidelines present the minimum criteria in bolded font while other guidelines are presented in normal font.

REFERENCES


CHAPTER 2. STATION PLATFORM

Of all the modal access points, the station platform is one of the key components of the station area. A primary function of the station platform is boarding and alighting of passengers. Other functions include, but are not limited to, waiting, ticket purchasing, and obtaining transit information. Because this is a key component, Chapter 2 discusses the design features necessary to enhance mobility.

Boarding and alighting area

The boarding area must be designed in such a way that enables patrons to board and alight safely. Boarding and alighting space should be free of obstacles such as trash receptacles, bike racks, and benches for seamless movement of patrons, especially physically challenged passengers. Boarding and alighting of passengers occurs as soon as a transit vehicle comes to a complete stop and takes place at the edge of the platform. Unlike bus stops, train stations do not have a landing pad for patrons using wheelchairs. The edges of the platform must be identified by a 24 inch wide detectable warning strip along the entire length and at the unprotected ends [1]. The warning detectable strip enhances safety by alerting visually impaired passengers to the location of the platform edge.

Figure 2.1 Tactile surface along the platform

Boarding types

There are two types of platform boarding, level and non-level boarding.

Level boarding

Level boarding is defined as involving a horizontal gap of no more than three inches, and a vertical gap of no more than 5/8 inch [2]. Level boarding provides fast,
easy loading and alighting because no vertical movement is involved. It further offers easier loading for baby strollers, elderly and disabled passengers not requiring a wheelchair lift, and passengers carrying packages. Unlike when mechanical devices are used, boarding for the disabled causes little delay in operations. For efficient flow of patrons entering and exiting the rail car, a platform design that allows for level boarding is recommended. Figure 2.2 shows an example of a level boarding system.

Figure 2.2 Level boarding

Non-level boarding

Non-level boarding involves passengers stepping up to enter the vehicle (Figure 2.3). With such systems, steps are needed as the platform level is lower than the vehicle floor level. Non-level boarding exists in many mature commuter rail systems. It also continues to be used for intercity rail systems such as AMTRAK services, which have relatively long dwell times. The height of commuter rail vehicles above the platform floor is typically smaller when compared to the AMTRAK vehicles.

Figure 2.3 Non-level boarding

Non-level boarding is acceptable but not recommended for BRT and rail services that offer commuter services. For stations with non-level boarding, either a mini-high platform or a mechanical lift should be provided to facilitate access for physically challenged passengers. Non-level boarding systems have some disadvantages for seamless movement. Most passengers must climb steps into the vehicle, which makes loading slower than using level boarding. Physically challenged passengers
such as people in wheelchairs can access the vehicle only through the mini-high platform or by using mechanical lifts. Because of the inconvenience of using the mini-high platform and lifts, only wheelchair passengers will generally use them. Others who may have difficulty climbing into the vehicle will climb nonetheless or opt to use other modes of transportation other than transit.

**Platform configuration types**

There are a number of possible platform configurations. These may include side, center, combined side/center, single, and split type [3]. These are named for their location relative to the train, i.e., on the side of a train, in the center of two trains. Side and center platforms are the most commonly used. The choice of configuration type depends on the type of transit system, right-of-way, geometry of tracks, and whether the station is accessed by grade or at grade crossing. Figures 2.4 and 2.5 depict the side and center configurations, respectively.

**Platform length**

The length of the station platform depends on the length of the train or bus that use the station plus at least 50 feet of tangent section at each end. Trains/vehicles used in different transit systems have varying dimensions [4]. Buses used for BRT systems
range from 50 to 80 feet in length while light rail systems typically consist of 50 to 80 feet per vehicle and up to four car trains. The overall length of a typical commuter train ranges from about 150 to 500 feet. For heavy rail, vehicle length ranges between 40 to 70 feet per car and could have up to 10 car trains. Considering vehicle dimensions, platforms for BRT systems are expected to be shorter when compared to other systems. The platform length will vary for the other systems based on the type of vehicles expected to be used and the projected maximum number of vehicles per train.

**Platform width**

The platform is used for boarding, alighting, waiting, and walking. The platform also accommodates amenities such as benches, ticket booths, vending machines, and wayfinding installations. The Americans with Disabilities Act Accessibility Guidelines (ADAAG) requires a clear width of at least 60 inches (5 feet) to allow a person in a wheelchair to make a turn around an obstruction [5]. This is in addition to 24 inches (2 feet) tactile surface along the platform edge. A minimum of 7 feet clear width should therefore be maintained. Additional width is required to accommodate elements such as benches, signage, ticket machines, telephone booths, and other pertinent amenities. Other structural members such as columns and walls should also be treated as obstructions, hence their sizes should be deducted from the effective clear width. A minimum overall platform width for side platform configuration should be 12 feet [6] with 30 feet preferred [7]. For center platforms, a minimum width should be 16 feet (30 feet preferred) [7]. Cross-section sketches showing minimum clear width and overall widths for center and side platforms are shown in Figures 2.6 and 2.7, respectively.

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**Figure 2.6 Center platform minimum width**
Platform area

The primary function of the platform is to accommodate patrons as they wait to board a vehicle. The procedure for sizing the waiting area is explained in the *Transit Capacity and Quality of Service Manual* [8]. A typical minimum design value for passenger waiting areas is 5 ft$^2$ per person, which allows passengers to wait without touching one another. As a rule of thumb, the platform minimum area, excluding the 24 inch strip adjacent to the platform edges, should be designed to accommodate the peak 15-minute loading demand at 10 square feet per person or the peak 15-minute loading and alighting demand at 7 square feet per person [9].

Platform geometry

A key accessibility issue for boarding and alighting is the horizontal and vertical gap between the vehicle floor entrance door and the platform. Vertical and horizontal gaps lead to substantial difficulties for physically challenged passengers especially patrons using wheelchairs. Americans with Disability Act (ADA) compliance requires the horizontal gap between a car at rest and the platform shall be no greater than 3 inches, and the height of the car floor shall be within plus or minus 1.5 inches of the platform height [5]. Station platforms need to be located on essentially horizontal and vertical tangent (flat and straight) sections to ensure consistency in allowable gaps within the tolerance level along the station length. In case tracks have a vertical slope or curvature, the geometry of the platform edge should match that of the tracks to ensure level boarding. Platforms should have cross slopes of 1.5% to 2% for drainage purposes. Center platforms should slope down from the centerline of the station to the platform edge.
Conversely, side platforms should slope away from the tracks.

**Shelter**

Shelters provide passengers with comfort and protection from adverse weather conditions such as rain, wind, and summer sun. The shelter length is determined by the number of vehicles. For a four-vehicle train, a minimum shelter length of 60 feet is recommended [7]. It is a good practice to provide shelter along the entire platform length. Some agencies prefer to have small shelters distributed along the entire platform while others provide a continuous canopy over the entire length.

Shelter areas and circulation elements should have sufficient transparency to give adequate visual surveillance of these spaces for user safety and to discourage vandalism.

**Benches**

Transit users who experience difficulty standing benefit from benches while waiting for the transit vehicle. The number of benches would depend on the length of the shelter, ridership, and the frequency of service among other factors. A minimum of four benches per station is recommended for a 60 feet long shelter [7]. In another design criterion, a minimum of 24 seats per platform distributed to at least four locations along the platform and protected by shelter canopies is recommended [9].

**Fence**

Fencing is normally provided between tracks at stations with low-level platforms to discourage pedestrians from crossing the tracks. Platforms shall be separated by a low fence. A fence centered between the two tracks provides a barrier to prevent passengers from crossing the tracks. The center fence should be at least 3.5 feet higher than the top of the highest rail [9]. It is a good practice to extend inter-track fence beyond the platform on each end where site conditions permit to discourage patrons from crossing railway tracks at locations other than railway pedestrian crossings. A distance of 200 feet beyond the end of the platform is recommended [9]. Some agencies install inter-track fence along the platform spanning through the
pedestrian railway crossing and a security fence (at least 6 feet tall) after the crossing for added safety.

Furniture arrangement

The arrangement and placement of station furniture should be in such a way that it optimizes usage of space, and more importantly improves mobility and safety of patrons as they use the platform. All amenities should be placed at least 7 feet from the edge of platform. An arrangement that improves clear width is encouraged. Figure 2.10 shows a poor arrangement of seats because it reduces clear width and may impede movement for patrons with visual disabilities. An arrangement that takes advantage of spaces between columns could increase clear width by about 2 feet (Figure 2.10).

Figure 2.8 Separation and security fence

Figure 2.9 Separation fence

Figure 2.10 Poor arrangement of seats

Figure 2.11 Good arrangement of seats
REFERENCES


4. Reconnecting America: Transit Technology Worksheet


7. FasTracks Guidelines for Transit Access, Denver, Colorado.


CHAPTER 3. SIGNAGE

In addition to station platform design, signage plays an important role in enhancing intermodal connectivity. Proper signage and wayfinding information is critical in ensuring seamless, convenient, and safe movement to and from a transit station. Signage can be categorized in four groups i.e., regulatory signs (inform user of regulation), warning signs (inform users of hazards), guide signs (navigation information), and motorist information signs (provide additional information). This chapter discusses signs related to wayfinding – mainly guide and motorist information signs. TCRP Report 12 - Guidelines for Transit Facility Signing and Graphics [1] defines the term wayfinding as used to describe the process of reaching a destination, whether in a familiar or unfamiliar environment.

Wayfinding signage is the most prominent, and therefore, the most vital communication tool of any public transit system. There are two major elements that must be considered when implementing a system-wide wayfinding signage program;

1) signage should be designed so that it facilitates clear, concise, universal communication from the transit authority to its riders; and 2) the placement of the signage so that passengers can locate necessary ridership information with ease[2]. A variety of wayfinding information is needed by passengers using different transportation modes to access transit. Wayfinding information and signage is needed at different stages of the trip from approaching the station to boarding a transit vehicle and vice versa.

Approaching the station

Passengers have to find the transit station before they can use the transit system. The Manual on Uniform Traffic Control Devices (MUTCD) [3] provides guidance on transit identification signage. Figure 3.1 shows the standard MUTCD sign while Figure 3.2 shows a customized station identification sign at Scaleybark station in the Charlotte light rail system operated by Lynx.
The use of landmarks that distinguish the station from other nearby facilities can help people locate it. Passengers who are unfamiliar with the transit station could identify the location of the station by unique signage such as a station identification sign with the logo of the transit system, name of the station, and a train station symbol. Consistency of station identification signs throughout the transit system is pivotal for easy station identification. Figures 3.3 and 3.4 show identification signs of two different transit stations in the Washington, D.C. Metro system with sign appearance kept consistent. Additional information provided by color codes (strips around the sign in Figures 3.3 and 3.4) indicate lines/routes served by the station.
Wayfinding at the station

There are wayfinding features specific for passengers using different modes of transportation to access the transit station. Pedestrians could walk directly to the platform upon identifying the location of the station while passengers who would need to change modes from automobiles, buses, and bicycles would need to either access parking facilities or loading/unloading facilities before approaching the platform.

Passenger accessing the station using private automobiles

Passengers that access the transit station using private transportation are expected to park their vehicles at the Park-and-Ride facility. Signage showing the location of the Park-and-Ride facility serves as guidance to passengers accessing the transit station by private automobiles. The standard PARK & RIDE sign (Figure 3.5) from the MUTCD [3] can be used to direct passengers to Park-and-Ride facilities. The sign shall contain the word message Park & Ride and directional information (arrow or word message, preferably, an arrow). The transit logo on the Park & Ride sign confirms to passengers that the parking facility is part of the transit system. The sign can be altered and used for wayfinding of Kiss-and-Ride facilities as shown in Figure 3.6.
Passenger accessing the station by bicycle

Effective signage can encourage more bicycling by leading people to bikeways and by creating a safe and efficient transportation option for commuters and visitors to the transit systems.

Bicyclists would need to park their bicycles at the bicycle parking facilities before boarding the transit vehicle. There might be exceptions in some cases whereby bicycles are allowed in transit vehicles depending on the transit agency policy. The Bicycle Parking Area sign (Figure 3.7) may be installed where it is desirable to show the direction to a designated bicycle parking area. The arrow may be reversed as appropriate.
Bus

FDOT published Design Handbook for Florida Bus Passenger Facilities, *Accessing Transit* [4] which can be downloaded at [http://www.dot.state.fl.us/transit/Pages/2008_Transit_Handbook.pdf](http://www.dot.state.fl.us/transit/Pages/2008_Transit_Handbook.pdf). The handbook has extensive discussion on the principles of design and wayfinding at bus facilities. Signage at bus stops (Figure 3.8) provides passengers with needed information about the transit system and the route serving a given stop. The information provided must be complete, yet concise, and should accommodate all passengers. At a minimum, the information provided on a bus stop sign must include bus symbol, accessibility symbol, route number(s) and destination(s) for routes serving the stop, phone number for transit system information, stop name, and a stop identification number [5]. The MUTCD does not stipulate a standard bus stop sign. However, the dimensions and placement of the bus stop signs should be MUTCD compliant.

Wayfinding at the platform

The wayfinding and signage system at the platform must include information resources that make passengers aware of schedules, where and when specific vehicles are arriving and departing, the location of station amenities, late breaking news on schedule changes, and other announcements. The ability to use these resources effectively is critical to the passenger. According to TCRP report 12 [1], platforms and boarding areas should be signed to ensure that 1) those waiting on the platform can identify the facility they
are in and facilities or stations that are served from that platform; 2) those arriving on the vehicle can look out of the windows and see the name of the facility or station; and 3) those arriving can find their way from the platform to their destination through the facility or station.

**Graphic wayfinding**

Graphic information is the most direct way for passengers to find their location. Typical graphic wayfinding information includes systems made up of text, pictograms, maps, photographs, models, and diagrams. Passengers who are unfamiliar with the transit station would need to observe, read, learn, and comprehend these systems as they make their way through the transit station. Graphic devices and the location of signage should be consistent throughout the system. Fonts associated with graphic signage should be large enough to be seen at a distance and easy to read, have contrasting text and background, and be located overhead, in the most visible position. Acceptable font style, case, character width, thickness, spacing, and height for transit wayfinding signage are described in TCRP report 12 [1] and TCRP Report 45 [6].

**Pictograms**

Pictograms are used to reinforce the text message. They provide concise and comprehensible directional, informational, and identification messages. International symbols are normally used. Pictograms often transcend language barriers in that they can communicate effectively to riders who cannot read or do not understand the local language. Figure 3.9 shows an example of pictograms in Hong Kong. A list of most international symbols used for transit wayfinding purposes is in TCRP Report 12 [1]. The use of international symbols is a major aid to the traveler who has sight but cannot read the available languages. Pictograms can be used to identify the key locations for passengers, such as platforms and routes they serve, ticket counters, elevators, escalators, public telephones, vending machines, etc.
Bulletin board

Message boards can be used to display basic transit system information including schedules, fares, route maps and other pertinent travel information. The bulletin/message board should include information only necessary for trip information. Most bulletin boards are encased in glass or plastic to discourage the posting of advertisements such as job announcements or other activities. Examples of clear and cluttered message boards are shown in Figures 3.10 and 3.11, respectively.

Video/computer monitors

Most bulletin boards provide static information, general information regardless of unpredicted changes. For example, message boards do not always have the
same late-breaking information that is provided by automated audio messages. Real-time information such as train schedule and change in track can be dynamically posted on monitors as they become available. Figure 3.12 shows an example of the type of information which could be displayed on video monitors.

Public address announcements

Passengers with different sensory impairments must be able to get late-breaking travel information as it becomes available. People with hearing impairments for example, may miss information that is not available on monitors or dynamic message boards like reasons for delays and track changes. On the other hand, people with visual impairments may need to get such information using medium other than monitors and boards. Public address announcements should be used concurrently with dynamic visual announcements.

Route maps

Route maps provide useful directional information to travelers. There are two main types of maps that can be used for wayfinding; geographic and schematic maps [6]. The differences between the two map types are described next.

Geographic maps

Most transit riders use route maps for trip planning. Geographic maps (Figure 3.13) display a complete transit route, and the roadway network in the vicinity of the transit system. Color codes associated with legends are normally used to illustrate different features described on the map. Other pertinent travel information such as location of airports, bus stops, and intermodal information could be included in the detailed maps. Such maps are also
provided at transit stations in forms of brochures. Many transit agencies include a detailed map on their websites to facilitate pre-trip planning.

**Schematic maps**

Due to the level of detail of geographic maps, they can only be effectively used by passengers who can approach the sign more closely, and take as much time as they want to read it. Passengers who are on board an en-route transit vehicle cannot easily read information in a detailed map because of vehicle movement. Simple maps such as the one depicted in Figure 3.14 eliminate unnecessary information and present riders with only the essential information needed to navigate the system. Such maps are also effective for passengers waiting at the platform who need to know only where they are in reference to where they are going. The information conveyed by these simple maps can be accessed by many transit users at a time as they do not need to be close to the map to comprehend the displayed message.

**Kiosks**

Kiosks are facilities that serve as satellite transit offices. Riders can use kiosks to obtain information that they missed
wayfinding signage. The following two sections describe two types of kiosks used at transit stations.

**Kiosk with attendant**

First time transit users would most likely need to ask for directions. Attended kiosks offer personalized wayfinding service whereby transit agency staff could answer questions and provide information necessary to guide riders unfamiliar with the system. Apart from offering directions, kiosks can provide other services such as ticketing or assistance in automated ticket transaction, security, lost and found service, etc. A manned kiosk should be located where it can be seen by all passengers as they enter or leave the platform.

**Interactive kiosks**

An interactive kiosk (Figure 3.15), also known as a self-service kiosk is a computer terminal that provides transit information electronically through hardware devices that work in combination with self-service software. The method of input is a keyboard, touch-screen, or both. The operation of interactive kiosks should be simple and intuitive to enable riders with any level of computer knowledge to use the kiosk. A number of transit agencies have installed interactive kiosks with features amenable to visually impaired passengers. Some of these kiosks, referred to as talking kiosks, feature a tactile/talking map with a standard telephone style keypad [7]. Passengers use one or both to access expertly crafted wayfinding information to enhance their freedom and independence as they navigate the transit system. Information is delivered simultaneously in clear, human speech and high contrast large print video display.

![Interactive kiosk used by a rider with visual impairment](image)
Tactile signs

Visual information alone does not help transit users who cannot see it. Talking signs, tactile maps, and tactile tiles used as guide strips are useful in helping people with visual impairments.

Tactile signs provide wayfinding information to riders who have poor vision. Design requirements for tactile sign typography are described in TCRP Report 12 [1]. Visual and tactile signs are normally combined to reduce the number of signs in the facility.

Figure 3.16 Route station and destination sign - combined visual and tactile sign [1]

Assistive listening systems

Most stations use public address systems for providing real-time wayfinding information. There are several assistive listening systems that can be used to convey auditory wayfinding information to people with hearing impairments. These hearing aids such as earbuds or headphones attached with telecoil-equipped hearing aids use sound conveyance systems such as FM systems, inductive loops, infrared, and AM systems to transmit audio announcements in clarity [1].

REFERENCES


CHAPTER 4. GREEN ENGINEERING INITIATIVES

Best practices for transit station design should include elements on environmental protection and energy efficiency to reduce their carbon footprint and ensure the sustainability of the environment for future generations. Green engineering design is among the suggested strategies to accomplish this objective. For transit stations to provide the least negative impact to the environment, practices such as reducing and recycling waste, reusing materials, minimizing energy usage, and promoting the use of products made of recycled materials should be incorporated in the design. This chapter explores green engineering initiatives for environmentally friendly transit station design.

Use of recycled materials

Recycling involves processing used useful materials into new products, thus reducing energy consumption and pollution associated with the production of products made of fresh raw materials. Wherever possible, features consisting of recycled materials should be employed in transit stations. The following sections offer suggestions of features made of recycled materials.

Sidewalks

One alternative to traditional concrete or asphalt sidewalk is the use of modern flexible sidewalk systems made of recycled rubber (Figure 4.1). A long term cost benefit in using recycled rubber sidewalk [1] is that they require less maintenance than that of traditional materials. The flexible material promotes pedestrian traffic while reducing noise levels, and the porous nature and flexibility can benefit adjacent tree roots and minimize the need for root cutting. Recycled rubber materials retain less heat, limiting the heat island effect found in many urbanized areas, and can be more easily replaced than traditional materials.
Recycled concrete
Traditionally, demolished concrete and asphalt is treated as waste. However, if crushed and sorted, demolished concrete could serve as an effective source of aggregate with equivalent or better engineering properties than traditional aggregates. Reclaimed Portland cement crushed into a course granular material can be used as a substitute for traditional crushed rock. Several transit agencies have used this environmentally friendly initiative in the construction of circulation roads, Park-and-Ride lots, and sidewalks.

Recycled bollards
Bollards are traditionally made of steel, concrete, or plastic. The regional light rail system for the Portland, Oregon, area was the first to make use of bollards made from recycled plastic [2] for a cost of 20% less than if steel bollards were used.

Recycled benches
Benches produced of recycled or renewable materials (Figure 4.2) offer advantages over traditional materials such metal and concrete. Benches made of recycled plastic require less maintenance and provide long term durability against cracking. Renewable materials, such as wood, require more maintenance than recycled plastic, but offer more comfort for users when exposed to hot and cold temperatures. Light colors are preferred as dark colors are relatively hotter.
Shelters
Shelter panels and receptacles made of recycled materials are gaining popularity. Portland TriMet replaced graffiti covered glass-panel shelters with attractive pattern designed shelters constructed of sandblasted recycled materials to deter graffiti [3]. Various designs of both free-standing, as shown in Figure 4.3, and mountable receptacles produced of recycled materials are now widely available [4].

Solar energy
The use of solar energy offers environmental benefits such as reducing air pollution, offsetting greenhouse gases, and conserving energy. Solar technology is currently being used to generate power for different transit station purposes. The following sections illustrate potential uses of solar energy at transit stations.

Station power generation
Because structures for large transit stations can span several hundred feet in width and sometimes several thousand feet in length, many transit agencies have implemented solar technology in the way of solar roof panels to provide power. Stillwell Avenue station in New York City increased its energy efficiency by up to 30% using 100 kW photovoltaic roof and 200 kW fuel cell systems [2]. The Stillwell Avenue station in New York City (Figure 4.4) integrates 2,730 photovoltaic panels which generate 250,000 kWh of electricity annually. The power generating capability of this roof’s solar technology provides up to 65% of the station’s electricity during the summer months for an average of 15% over the course of one year, greatly reducing the
consumption of electricity from the city's grid. The overall power generated is capable of supporting up to 40 single family homes. This could be increased in warmer, summer climates and year round sunshine such as Florida.

Figure 4.4 The Stillwell Avenue subway station in New York City [5]

The Trenton Amtrak New Jersey Transit Center implemented a solar technology initiative expected to eliminate 141 tons of carbon dioxide emissions annually [6]. In addition to producing clean energy for each parking structure, each solar array is equipped with a 110-volt charging station for plug-in hybrid and electric vehicles. Excess power can be sold back to the grid.

Figure 4.5 Solar powered parking lot lighting

Lighting
Solar powered lights are common in many transit stations. Solar lighting applications include parking lots, bus shelters, advertising panels, direction signposts, platform canopies, bus stop signs, and pedestrian pathways. Figures 4.5 to 4.11 show various examples of these uses. In areas that receive sunshine most of the year, the use of a solar canopy for coverage of surface parking similar to the one used at La Sierra transit station in California [7] can benefit both transit users and adjacent facilities as well (Figure 8.11).

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Figure 4.6  Bus stop and advertisement powered by solar energy

Figure 4.7  Solar powered bus stop signage

Figure 4.9  Pathway illuminated by solar energy

Figure 4.10  Solar powered emergency phone
Pervious pavements

Pervious concrete offers a unique and innovative means to manage storm water. It is made with little or no sand, producing a strong and durable pavement with voids that allow rain water to pass through where soils permit. Impervious pavements, particularly at Park-and-Ride facilities (Figure 4.12), collect pollutants such as oil, anti-freeze, and other automobile fluids that can be washed into natural water bodies when it rains [8]. Pervious pavements capture the first flush of rainfall and allow it to percolate into the ground, whereby soil chemistry and biology can treat the polluted water naturally. Studies conducted on the long-term pollutant removal in porous pavements suggest high pollutant removal rates [9]. Other advantages of pervious pavements include reduced retention areas, increased aquifer recharge, reduced peak water flows, and minimized flooding. The use of pavers at Park-and-Ride lots and sidewalks serve the same purpose. If pavers are used, considerations should be made for pedestrian pathways as they might present additional difficulty to wheelchairs and transit riders using canes or walkers.

Figure 4.11 Parking lot covered by photovoltaic solar panel (La Sierra train station, California) [7]

Figure 4.12 Park-and-Ride pervious asphalt pavement
Vegetation

Trees
The use of trees is encouraged to provide shade to passengers exposed to sunshine, particularly pedestrians and bicyclists. Additionally, trees offer environmental benefits such as providing storm water retention and reducing pollution. Trees are typically planted alongside bikeways and pedestrian pathways.

Groundcovers
The use of groundcovers in lieu of trees in sidewalk planting areas reduces storm water runoff, irrigation water needs, and requirements for future petrochemical fertilizer and pesticides [2]. In addition, groundcovers reduce the frequency of mowing typically performed with gasoline-burning equipment. When mature, these plantings provide full ground coverage and total interception of rainfall to limit the impacts of erosion.

Drought tolerant plants
Several agencies including the Portland TriMet [2] transit agency have adopted an “irrigate-to-establish” only philosophy. Under this philosophy, plantings that need irrigation only for the first few seasons are used to reduce the long-term need of irrigation water. Other strategies such as using native and drought tolerant plantings can also be employed to eliminate or reduce the use of irrigation water. When irrigation is required, the use of recycled water is strongly encouraged.

Biofilters
Biofilters is a natural way of using a combination of certain species of plants and soil gradation for cleaning stormwater runoff by removing sediments, turbidity, heavy metals, and other pollutants [10]. Examples of biofilters include vegetated swales also known as bioswales (Figure 8.13), rain gardens, constructed wetlands, and phytofilters.

Energy efficient structures
Transit stations typically have a building structure ranging from a simple platform canopy to a complex multi-story intermodal center. The importance of energy efficiency feature consideration in the design of such structures should not be ignored. The use of energy efficient lighting and heating
would reduce energy consumption. To help improve indoor air quality, environment-friendly paints, solvents, and heating and cooling systems should be used.

Whenever possible, natural lighting should be incorporated to complement or replace electric lighting during daytime hours. This can be achieved by installing roof panels with skylights that provide natural light to the station’s interior [5]. Charlottesville’s Downtown Transit Station [12] installed a cooling roof system that offsets the heat island effect by using materials that have high emittance and reflectance. The result is a roof that stays cooler during peak summer temperatures, thereby reducing the building’s need for air conditioning, and reducing their overall carbon footprint.

Vegetation strip on BRT lane

Some agencies have implemented a green BRT lane by which a vegetation strip is planted on a section of the BRT exclusive lane (Figure 4.14). The vegetation strip can be used to collect some storm water runoff. The use of highly permeable soil underneath the vegetation strip can enhance storm water drainage.

REFERENCES

2. Cooper, S. and Batty, S. Environmental and Sustainable Elements in Light Rail


CHAPTER 5. FACILITY PROTOTYPES

This chapter provides prototypes of transit station facility layouts for enhancing intermodal connectivity. The prototypes provide insight on how to design transit stations with seamless interconnectivity of all modes of transportation including walking, bicycles, buses, paratransit, taxis, and private automobiles.

Rail station with side platforms

Figure 5.1 depicts a typical layout for a simple at-grade passenger rail station with side platforms. Side platforms distribute passengers for each direction of travel, hence accommodating large volumes of patrons.

Rail station with center platform

A prototypical site plan of the passenger rail station with center platform is depicted in Figure 5.3. Passengers for both directions share the waiting area. Figures 5.3 and 5.4 are sections of Figures 5.1 and 5.2, respectively.

BRT station layout

Typically, BRT vehicles use a median lane. Most BRT stations therefore utilize split center platform configuration. This configuration minimizes the right-of-way requirements for the station and reduces pedestrian congestion at the median. A center platform width of at least 20 feet is desirable [1]. Figure 5.5 shows a plan view of a typical BRT station. Figure 5.6 shows a section of a BRT station while Figure 5.7(a) depicts a BRT side platform configuration, and Figure 5.7(b) shows a 3D view of a BRT station.

Intermodal connections

The aforementioned prototypes depict seamless and safe connection of different modes of transportation at the station. Preference in terms of proximity to the station and right of way is given in the following order: 1) pedestrians; 2) bicyclists; 3) paratransit; 4) buses; 5) vehicles using Kiss-and-Ride; and 6) vehicles using Park-and-Ride.
**Pedestrians**

Safe and convenient pedestrian access to the station is pivotal for station intermodal efficiency. The direction of pedestrian pathways should be as direct as possible to discourage pedestrians from using unintended shortcuts. Pedestrian movement should be separated from vehicular movement as practical. A raised pedestrian walkway between parking stalls (Figure 5.1) is a better approach than having pedestrians walk behind parked vehicles.

**Bicycles**

Separating bicycles and motor vehicle traffic is the safest way of accommodating bicyclists. To prevent bicyclists from riding bicycles on pedestrian walkways, signs to instruct bicyclists to walk their bicycles to the station can be used (Figure 5.8). The Association of Pedestrian and Bicycle Professionals (APBP) suggests that bicycle racks should be located no more than 120 feet from the platform to allow for direct and convenient access to the entrance [3].

**Buses**

Right-of-way priority should be given to buses and paratransit vehicles. Bus loading and unloading should be separated from other modes as practical (Figures 5.1 and 5.2). A minimum turning radius of 50 feet should be provided to account for buses with bicycle racks.

**Pick/Drop-and-Ride**

Pick/Drop-and-Ride provisions should typically be closer to the station compared to the Park-and-Ride facility. Separate storage bays for taxis, Kiss-and-Ride, and disabled Pick-and-Drop should be provided (Figure 5.1). The design vehicle for Pick/Drop-and-Ride facility should be the longest anticipated vehicle, such as a limousine. The minimum turning radius of 38 feet is required to accommodate a limousine U-turn maneuver.

**Private automobiles**

Park-and-Ride facilities should be designed for efficient circulation (Figure 5.1) to allow for private automobiles to access the station.
REFERENCES


Figure 5.1 Site plan of a side platform rail station
Draft Guidelines for Enhancing Intermodal Connections at Florida Transit Stations, June 2010
Figure 5.3 Cross section of side platform rail station

Figure 5.3 Cross section of center platform rail station
Figure 5.5 Plan view of a BRT station
Draft Guidelines for Enhancing Intermodal Connections at Florida Transit Stations, June 2010

Figure 5.6 Cross section of a BRT station

Figure 5.7(a) View of BRT downtown station with side platform [2]

Figure 5.7(b) View of BRT station with split center platforms
Figure 5.8 Detailed diagram showing bicycle access to station
Figure 5.9 Detailed diagram showing pedestrian access from parking lot