TCRP
Web-Only Document 44:

Literature Review for Providing Access to Public Transportation Stations

Kathryn Coffel
Jamie Parks
Conor Semler
Kittleson & Associates, Inc.
Portland, OR

David J. Sampson
Chris Henry
Guillermo Calves
AECOM
Southport, CT

Carol Kachadoorian
Toole Design Group, LLC
Hyattsville, MD

Herbert S. Levinson
New Haven, CT

Joseph L. Schofer
Northwestern University
Evanston, IL

Contractor's Final Report for TCRP Project B-38
Submitted March 2009

Transit Cooperative Research Program
TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

ACKNOWLEDGMENT

This work was sponsored by the Federal Transit Administration (FTA) in cooperation with the Transit Development Corporation. It was conducted through the Transit Cooperative Research Program (TCRP), which is administered by the Transportation Research Board (TRB) of the National Academies.

THE NATIONAL ACADEMIES

Advisers to the Nation on Science, Engineering, and Medicine

The **National Academy of Sciences** is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. On the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Ralph J. Cicerone is president of the National Academy of Sciences.

The **National Academy of Engineering** was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. Charles M. Vest is president of the National Academy of Engineering.

The **Institute of Medicine** was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, on its own initiative, to identify issues of medical care, research, and education. Dr. Harvey V. Fineberg is president of the Institute of Medicine.

The **National Research Council** was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both the Academies and the Institute of Medicine. Dr. Ralph J. Cicerone and Dr. Charles M. Vest are chair and vice chair, respectively, of the National Research Council.

The **Transportation Research Board** is one of six major divisions of the National Research Council. The mission of the Transportation Research Board is to provide leadership in transportation innovation and progress through research and information exchange, conducted within a setting that is objective, interdisciplinary, and multimodal. The Board's varied activities annually engage about 7,000 engineers, scientists, and other transportation researchers and practitioners from the public and private sectors and academia, all of whom contribute their expertise in the public interest. The program is supported by state transportation departments, federal agencies including the component administrations of the U.S. Department of Transportation, and other organizations and individuals interested in the development of transportation. **www.TRB.org**

www.national-academies.org

Table of Contents

Introduction

Working Paper #1 provides the results of the literature review component of Task 1 of the TCRP B-38 project. The paper is divided into six main sections:

1. Access issues and agency guidelines for transit access;
2. Evaluation tools;
3. Transit-Oriented Development;
4. Park-and-ride/Kiss-and-ride;
5. Transit feeder service; and
6. Pedestrian and bicycle access.

Based on our review, the following key points emerged from the review:

- Access planning must effectively consider local characteristics (e.g. demographics, land use) in order to develop a balanced and successful multi-modal access plan
- The body of literature on access mode choice shows that while characteristics of individual travelers play a large role in access decisions, external factors that can be affected through policies and design also play a large role.
- There are several well-established evaluation tools available to assess the quality of pedestrian, bicycle, and transit facilities which will be used as a starting point for Tasks 3 through 5.
- Transit-Oriented Development has a number of environmental benefits and the potential to increase ridership; however, to be successful TOD must incorporate partnerships and be sensitive to local market conditions.
- Park-and-ride facilities provide a large portion of ridership for many high-capacity transit systems, and will likely continue to play a large role for the foreseeable future to maximize transit ridership and availability.
- Where parking demand exceeds capacity, research shows that parking pricing and TDM measures can encourage auto drivers to switch to other access modes, but can run the risk of reducing ridership if not priced appropriately.
- Transit feeder services that are both time-competitive and cost-effective are difficult to provide, but have potentially major benefits. Potential strategies to accomplish these dual objectives include flexible routes, ITS, and fare coordination.

- Pedestrian access to transit stations is determined by many factors, including distance, urban design, pedestrian facilities, crime, and characteristics of individual travelers. While transit agencies cannot affect distance, agencies do have the potential to increase walking mode shares through other improvements.

- Surveys of walk access trips show that many pedestrian walk between 0.5 and 1 miles to access transit, indicating that the traditional focus on only the first half mile by underestimate the actual potential for walking trips.

- Bicycle access is largely dependent on factors outside of transit agency control (e.g. quality of the bicycle network); however, provision of bicycle parking at transit stations significantly increases bicycle access.

The information provided within this paper is just that: information. This information will be used by the research team to select stakeholder interviews in Task 2, and develop alternative typologies, decision factors, and evaluation tools in Task 3-5. Working Paper #2, the product of Tasks 2 and 3, will identify the typology of access alternatives and document the results of stakeholder interviews. Working Paper #3, the product of Tasks 4 and 5, will present the key decision-making factors and appropriate evaluation tools based on the team's evaluation of the information presented in the literature review and assembled in Working Paper #2.

An updated version of this Working Paper will be provided in the Interim Report, to reflect comments received from the panel.

Access Issues

There is a substantial body of literature summarizing transit access issues, including several comprehensive transit access guidelines produced by transit agencies. This literature indicates that many agencies are planning for integrated, multi-modal access to high-capacity transit rather than focusing on a single access mode. In several cases (e.g. BART and WMATA), these agencies are prioritizing non-auto access trips due to both environmental benefits and the high-cost of providing facilities for automobile access.

In addition to considering multiple access modes, agencies are also considering how to address access for polycentric urban areas. Decentralization of American cities over the past 50 years has created the need for transit to destinations other than the CBD to be successful. Doing so requires transit access that considers suburban stations as both origins and destinations for transit trips.

At the same time, the research indicates that automobiles will continue to play a large role in transit access and that access planning must take local conditions into account to be successful. For instance, *TCRP82: Improving Transit Options for Older People* shows that the demographics of the population in the station area will affect access decisions. Similarly, making transit viable to serve lower density areas will require continued provision of park-and-ride facilities.

Finally, the results of *TCRP 118: BRT Practitioner's Guide* show that BRT and LRT share many characteristics and that well-designed BRT systems generate ridership equivalent to LRT systems. For B-38, this indicates that access planning for BRT will follow many of the same principles as those already established for LRT. One important distinguishing factor of BRT, however, is the opportunity to provide a "one-seat ride" where a single vehicle serves as both feeder and line-haul mode. This approach can reduce the need for station transfer facilities and parking.

RESEARCH

Transportation Research Record Volume 2042 – Intermodal Facilities and Capacity; Light Rail, Commuter Rail, and Rail Transit; and Major Activity Center Circulation Systems, 2008

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Factors that affect access decisions
- Evaluation tools

Line-Haul Mode(s) Considered:

☒ Commuter Rail	☐ Heavy Rail/Subway	☒ Light Rail
☒ Bus Rapid Transit	☒ Commuter Express Bus	☐ Ferries

Access Modes Considered:

☐ Auto ☒ Transit ☐ Bike ☒ Pedestrian

Summary: This research report contains 12 articles in three primary subject areas: Intermodal and Capacity; Light Rail, Commuter Rail, and Rail Transit; and Major Activity Center Circulation Systems. Key issues relating to station access addressed in the articles in this document include the relationship between service frequency and reliability and passenger arrival behavior (at stops or stations), the relationship between transit service quality and employment access, and the relationship between service orientation, bus-rail service integration, and transit performance in U.S. metropolitan areas (with populations between 1 and 5 million people).

"Investigating Consistency in Transit Passenger Arrivals" by Daniel Csikos and Graham Currie notes the positive relationship between transit service frequency and quality with ridership and passenger arrival behavior at stations. Specifically, more frequent and more reliable service sees more passengers arriving closer to the next scheduled trip, whereas less reliable, less frequent service sees more passengers waiting longer at stops. Arrival patterns are also more predictable for peak period commuter services vs. mid-day, off-peak services.

"Service Orientation, Bus-Rail Service Integration, and Transit Performance" by Jeffrey R. Brown and Gregory L. Thompson finds that most multi-destination (i.e., not single CBD) bus-and-rail systems that use rail lines as the network spine and buses as the ribs saw have seen increases in riding habit, defined as passenger miles per capita (as opposed to unlinked trips).

The restructuring of transit networks from single destination to multi-destination systems, using bus service to support rail spines, is generally seen as a positive growth factor for transit. Multi-destination systems attract more balanced loads by direction and time of day, thus increasing efficiency.

"Commuter Rail Circulator Route Network Design and its Implications for Transit Accessibility" by Nicholas E. Lownes and Randy B. Machemehl discusses the importance of circulator transit services to feed commuter rail lines, which have always been built on existing rights of way and infrastructure.

Access to commuter rail may involve more than one additional mode (walking plus bus). Therefore, service reliability is as important as convenience (walking threshold) and travel time.

Strategies for encouraging transit use include:

1. Using transit modes (bus, rail) to support a multi-destination network rather than a single CBD
2. Improving frequency and reliability of bus services to minimize wait times and anxiety of users waiting at stops
3. Three approaches are presented to supporting ridership of feeder services to rail
    a. Cultivate ridership at any cost (do not limit service based on assumptions of what passengers may consider convenient, i.e., walking distance)
    b. Minimize operating costs (limit route distance and operating burden)
    c. Balanced approach (account for walking thresholds while trying to minimize operating burdens)

Kittelson & Associates, Inc., Levinson, and DMJM+Harris, *TCRP Report 118, Bus Rapid Transit Practitioner's Guide*, 2007

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Evaluation tools
- Decision-making framework

Line-Haul Mode(s) Considered:

☐ Commuter Rail ☐ Heavy Rail/Subway ☐ Light Rail

☒ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☒ Bike ☒ Pedestrian

Summary: This guidebook provides information on the cost and effectiveness of BRT components (including stations). It provides evaluation tools and case study data.

This guidebook defines BRT and its components, provides guidance for planning BRT systems, provides a methodology for estimating BRT ridership that depends on specific BRT components and amenities, provides cost information for a range of BRT components and features, discusses the packaging of BRT components, and provides guidelines for land development at BRT stations. The guidebook's discussion of ridership forecasting techniques, transit-oriented development, stations, and station amenities can be applied to non-BRT transit modes and is potentially relevant to TCRP B-38.

Comments: This guidebook argues that BRT can result in ridership and land development impacts comparable to those of light rail if the investment in facilities and service is similar. Thus, for the purposes of TCRP B-38, BRT and light rail stations may not differ much in terms of station access needs and patterns where the services operate similarly and have comparable infrastructure. This is counter to the common perception that bus modes do not attract the levels of ridership and investment that rail modes do.

Burkhardt, McGavock, Nelson and Mitchell, *TCRP Report 82: Improving Transit Options for Older People, Volume 2, Final Report*, 2002

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Factors that affect access decisions

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☒ Heavy Rail/Subway ☒ Light Rail

☒ Bus Rapid Transit ☒ Commuter Express Bus ☒ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☒ Bike ☒ Pedestrian

Summary: The report includes sections on the demographics of older persons, travel patterns of older persons, transportation service quality measures, older persons' self-reported mobility preferences, transit agencies' perspective on older persons' mobility preferences, identified transit improvements that would benefit older persons, challenges to offering improved transit services to older persons, and strategies for implementing better transit services for older persons.

Content that is relevant to TCRP B-38 includes the following:

- Discussion of older persons' mobility limitations (e.g., ability to walk to and from stations and climate tolerance)
- Discussion of older persons' activity patterns, travel patterns, and locations of residence
- Identification of evaluation measures related to older persons' transit needs (e.g., Access to Stop/Shelter, Crime/Security, and Climate Control)
- Discussion of older persons' travel mode preferences (e.g., proximity to the travel mode)
- Discussion of the perspectives of both older travelers and transportation providers
- Identification of transit improvements that would benefit older persons (e.g., door-to-door service, boarding assistance, and minimization of physical barriers)
- Strategies for implementing better transit services for older persons (e.g., pedestrian access improvements)

Comments: This study has three products: the final report, a brochure, and a handbook (not reviewed). It is a useful study for TCRP B-38 because it provides detailed information about older persons' travel patterns as well as their access needs (such as access modes that recognize their sensitivity to climate and their ability to continue driving as they age). As a result, a station located in an area with a relatively high percentage of older persons (e.g., some areas of Florida) might recognize that the "station area" is not defined by the typical half-mile walk-access radius. Station planning in such an area might also consider that older persons are typically retirees who do not travel to and from work as non-retirees do, so station area parking needs should consider questions such as, "Will station-area parking be available to older persons when they need to use it, or will station-area parking be filled by commuters?"

Hoel and Roszner, *Transit Station Planning and Design: State of the Art*, 1976

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Factors that affect access decisions

Line-Haul Mode(s) Considered:

☐ Commuter Rail ☒ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☐ Auto ☐ Transit ☐ Bike ☒ Pedestrian

Summary: This document focuses on the planning and design aspects of rapid transit stations with emphasis on pedestrian access to and from the station platforms. It reviews design principles and standards, gives information about various components, reviews analytical approaches, and describes several design procedures.

Comments: The document is largely complementary to publications that deal with access to stations. Its design guides/rules of thumb need updating to reflect more current criteria. General bus interchange criteria are given.

Transit Station Access Committee, *56th Technical Council Information Report*, 1980

Applicable Guidebook Sections:

- Description of access alternatives and access issues

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☐ Heavy Rail/Subway ☒ Light Rail

☒ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☒ Bike ☒ Pedestrian

Summary: This document sets forth planning and geometric design guidelines for access to rapid transit stations by all modes – pedestrian, bicycle, bus, kiss-and-ride, taxicab, motorcycle, and park-and-ride. It suggests separation among these modes in the following order of priority: (1) between pedestrians and other modes and (2) between public and private transportation. It

contains a series of designs for bus loading and unloading zones, design vehicles and minimum turning paths, vehicular entrance drive details, motorcycle parking space, and parking space for the handicapped.

Comments: The document contains important concepts and information that will be valuable in formulating guidelines. However, the pedestrian capacity information has been superseded by the information contained in the Transit Capacity and Quality of Service and the Highway Capacity Manuals. There is little information on the internal design of transit stations.

AGENCY PLANS AND CASE STUDIES

Denver RTD Fastracks, *Transit Access Guidelines*, 2008

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Factors that affect access decisions
- Decision-making framework

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☐ Heavy Rail/Subway ☒ Light Rail

☒ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☒ Bike ☒ Pedestrian

Summary: Denver's RTD transit access guidelines provide rationale for access to rapid transit stations where pedestrians, bicyclists, transit buses, and private autos provide portions of the transit accessibility. The guidelines were designed with flexibility in mind to accommodate variability among stations. They were also intended to support compatible land use patterns, particularly transit-oriented development.

Section 2 describes access research and observed behavior by each access mode. RTD found that success in attracting people to walk to station depends on many different factors, which are summarized in the table below.

Hard factors are the overarching infrastructure and land use characteristics within a station area. Soft factors are those social elements, such as planning for TOD, or others that apply to the street scale comfort and level of amenities.

The second highest priority access mode comes from bus transfers. The quality of transit connections (as perceived by passengers) is a function of station design, service configuration, and customer behavior. The transfer facility design depends on the number of vehicles to be accommodated, traffic engineering considerations, pedestrian movements, and the surrounding development.

Bicycle accessibility design elements should be given consideration just after pedestrian and bus transfer access but ahead of other modes. Without a safe system in place for cycling, would-be bicycle commuters are discouraged from biking to the transit station. A safe system is one in which a transit customer can: safely connect to the station area from surrounding communities and bicycle facilities, easily find the transit station, and lock his/her bicycle in a secure and convenient location. Safe and coherent connections can be achieved through on-street bike lanes, bicycle paths, and wayfinding signage.

Variables that Influence Walking Behavior

Hard factors	Soft factors
Street Network:	TOD-friendly Master Plan in place
-Grid pattern	Quality of the pedestrian experience
-Sidewalk connections	Time
-Adequate pedestrian crossing signals	Comfort:
Land Use:	-Weather
-Density	-Landscaping and street trees
-Diversity (mix of uses)	-Flat Terrain
Station Design:	-Station condition (maintenance)
-Station served by multiple modes (bus and rail)	-Lighting
-Transit frequencies/headways	-Adequate station and platform cover
-Number of parking spaces	-Lack of crime
-Cost of parking/parking prices	
-Commercial services for transit users	

Source: PB PlaceMaking, February 2008

Auto access, which represents the largest share of access to RTD's LRT system, is primarily accommodated through kiss-n-ride and park-n-ride facilities.

Section 3 identifies RTD's proposed access guidelines and standards, which are intended to support implementation of the access hierarchy with the goal of achieving an optimal balance of access to the transit system. Guidelines for each mode are included.

The pedestrian guidelines seek to minimize or eliminate conflicts between pedestrians and vehicles by separation (plazas, at-grade crossing treatments, or overpasses and underpasses). They also intend to encourage walking by providing pedestrian priority in traffic control, direct connections, lighting and environment, wayfinding, and security.

Bus transfer access guidelines focus on ensuring passengers can successfully make connections. Specifically, the guidelines consider safety, physical site constraints, street design, development potential, and level of service and type of transfer activity.

Bicycle access guidelines address connections to/from station, wayfinding, and bike parking. Specifically, they include on-street bike lanes or multi-use paths for streets connecting RTD park-n-ride facilities, signage, and parking facilities in well-lit, highly visible areas.

The guidelines for auto access consider both kiss-n-ride and park-n-ride facilities. The kiss-n-ride guidelines encourage convenient placement for both pedestrians and motorists to discourage pick-up/drop-off activity locating elsewhere, design that maximizes vehicle turnover, facilitates traffic flow, and avoids conflicts, and allows one-way traffic flow for re-circulation. The park-n-ride guidelines include all pedestrian access guidelines. They also provide that in TOD station

area with a need for large parking capacity, it is preferable to have multiple park-n-ride sites rather than a single facility.

Comments: This document provides a good example of a comprehensive set of guidelines currently in use by major transit agency.

Bay Area Rapid Transit, *BART Station Access Guidelines*, 2003

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Evaluation tools
- Decision-making framework

Line-Haul Mode(s) Considered:

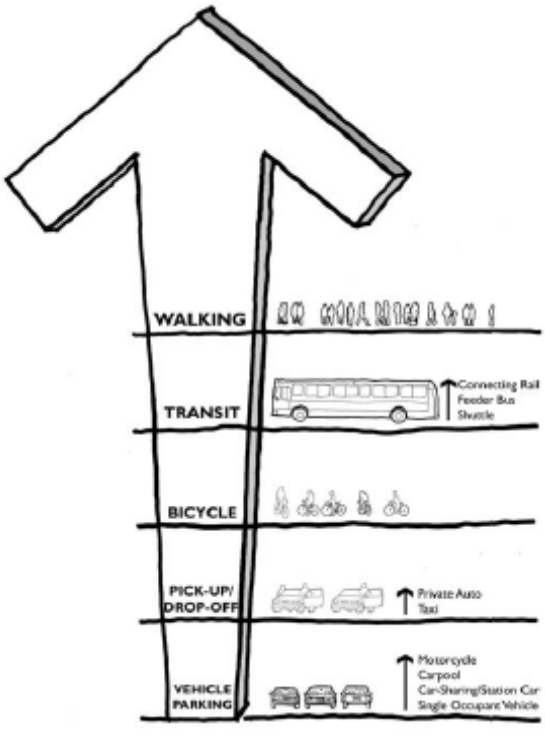
☐ Commuter Rail ☒ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☒ Bike ☒ Pedestrian

Summary: This document provides access guidelines intended to help BART optimize access to stations by all modes. Chapter 2 identifies policy context for each access mode, including key considerations. The document identifies an access hierarchy (shown here) dictating that BART will prioritize low-cost, high capacity modes. BART measures the success of these policies by access mode split at each station.



Chapter 3 lays out agency principles for wayfinding and again for each mode. These principles include:

- Pedestrian routes should be direct and designed to minimize conflicts
- Passengers should feel a strong sense of security
- Passengers should be able to quickly and easily orient themselves
- Create a network of safe, direct, and appealing walking routes to the stations
- Promote transit-oriented development close to BART stations.
- Platforms and bus stops should be within close proximity and enjoy safe access.

- Prioritize feeder transit service in order of transit activity.
- Work with local jurisdictions to provide direct, safe, and well-marked bike routes to BART stations

Chapter 4 *Planning for Imperfection* deals with conflicts associated with attempting to accommodate all modes, including competition for space and direct conflicts between modes such as bicycles and autos. The document identifies three guiding principles:

- **Position in the hierarchy of access modes.** Pedestrian access should be the highest priority, with provision for single-occupancy vehicles made only once other modes have been accommodated.
- **Cost per new rider.** Improvements that will do most to increase ridership at the lowest cost should be prioritized. To the extent possible, costs should be compared on a consistent basis across all modes, taking into account both operating and capital expenses, and land values and the opportunity costs of forgone joint development.
- **Context.** At some stations, particularly on the suburban edge, transit oriented development and pedestrian access improvements are more challenging. In many cases, this is due to auto-oriented, discontinuous street networks and stations that lie in freeway medians. Since it important to maintain provision for the many riders who have no alternative to driving and parking at a BART station, automobile access concerns can be given greater weight at these stations.

Comments: This document provides a good example of a comprehensive set of guidelines currently in use by major transit agency.

Washington Metropolitan Area Transit Authority, *Metro Station Access & Capacity Study*, 2008

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Factors that affect access decisions

Line-Haul Mode(s) Considered:

☐ Commuter Rail ☒ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☒ Bike ☒ Pedestrian

Summary: The WMATA Station Access and Capacity Study provides guidance for station access and capacity projects identified in the region's fiscally constrained Long Range Plan. It focuses on capacity and access issues as they pertain to autos, transit, bicycles, and pedestrians.

Metro's station designs give primary consideration to peak passenger flows, efficiency to maximize passenger movements under normal operating conditions, and safety to facilitate evacuation of passengers during an emergency. The passenger flow between each station level and element was analyzed and compared with standard or assumed capacity flow rates. The vertical flow between the surface and mezzanine, mezzanine and platform, and platforms at transfer stations were estimated. In addition, the study determined the passenger flow through horizontal elements such as faregate arrays and farecard vendors. These values, along with a variety of assumptions and calculations, were used to determine the peak 15-minute entry and exit volumes traveling on or through each station element. The resulting volume-to-capacity ratios were used to identify the stations most in need of attention.

Station access guidelines were issued by Metro in 2006 which established the general hierarchy of access to Metrorail stations. The guidelines also offer specific criteria for the placement and design of parking, Kiss & Ride lots, bus bays, bike racks and lockers, and sidewalks. The Station Access study collected mode-of-access data which were used to compare existing use and supply for parking, pedestrian, and bicycle facilities. This information was used to identify stations with possible access issues.

Future access needs focus on serving pedestrians and bicyclists. Data for population and employment growth within one-half mile of each station were collected and used to identify stations with future pedestrian and bicyclist needs such as sidewalks, improved street crossings, bicycle paths, and bicycle racks/lockers.

In addressing future access challenges, Metro seeks to accommodate the access needs associated with the increase in travel demand for all modes. One mode seen as growing in importance is feeder bus service, which provides access to more distant populations and reduces parking needs. The plan calls for Metro to identify future population centers without present Metrorail access and investigate the possibility of servicing those centers with feeder buses.

Metro identified station areas anticipated to experience the greatest amount of growth and assessed their pedestrian and bicycle needs. This assessment was based on existing bike rack and locker utilization, the presence of bike routes/facilities or sidewalks leading to the stations, and the presence of major roadways adjacent to the station. They determined that most of the pedestrian and bike access improvements would be made on land not owned by Metro. Therefore, Metro seeks to partner with neighboring jurisdictions and agencies to implement improvements, such as wayfinding, pedestrian-scale streetlights, street trees to provide shade, sidewalks, bicycle lanes or paths, bicycle lockers or racks, and improved pedestrian crossings at major roadways.

NJ TRANSIT, *Station, Operations, & Bicycle Facilities Planning Guidelines (Appendix 3.2 of Supplemental Draft Environmental Impact Statement for Access to the Region's Core project)*, 2008

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Factors that affect access decisions
- Evaluation tools

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☐ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☒ Bike ☒ Pedestrian

Summary: This document provides an evaluation of build or no-build additions to rail station parking facilities as part of Draft Environmental Impact Statement (DEIS) for a new rail tunnel from New Jersey to New York City and related rail service enhancements.

In addition to its program to expand parking facilities at rail stations, NJ TRANSIT works with local municipalities to provide feeder bus services to commuter rail and light rail stations. Station expansion is based on projected need and available land/capacity. Where parking shortfalls exist or are expected to exist, transit and community shuttles are seen as mitigating solutions.

NJ TRANSIT has in place a Station Access Program (SAP) to evaluate a plan for rail station access. Strategies of the SAP include:

1. Expanding existing parking facilities
2. Developing new parking facilities
3. Providing bus and community shuttle access
4. Improving bus/rail coordination
5. Enhancing pedestrian and bicycle pathways

Criteria for development of Community Bus Shuttle proposals for station access include:

1. Transit access options or problems that the service would help solve
2. A community's demonstrated administrative ability to market and carry out project
3. Financial commitment
4. Operational capability

TriMet, *Design Criteria Manual, Chapter 6: Stations*, 2005

Applicable Guidebook Sections:

- Description of access alternatives and access issues

Line-Haul Mode(s) Considered:

☐ Commuter Rail ☐ Heavy Rail/Subway ☒ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☒ Bike ☒ Pedestrian

Summary: This is one chapter of a larger design manual that lays out standards for designing for transit. Chapter 6 - Stations addresses aspects of light rail stations. The first section identifies the goals of a LRT station, recognizing that stations are central to modal interchange and key to the operation of the entire transit system. The stations must enhance the quality of the light rail trip, in order to attract and retain ridership. There are three main categories of design goals: architecture, interchange function (intermodal transfers), and community relationship.

The section of the chapter on site planning establishes the hierarchy of vehicular access modes as: Fixed route bus; taxi and paratransit (private or flexible route bus) drop off; auto drop off; bicycle parking; and auto parking.

The section on circulation and site requirements addresses design, and access to and around the station. Although most of the design objectives relate to design within the station, Community Enhancement is called out, with objectives to minimize impacts on local vehicular and pedestrian traffic, and to promote desired [community] growth.

Design guidelines for pedestrians specify providing separate facilities for pedestrians entering and leaving the station, where feasible, to provide an attractive pedestrian environment and reduce conflicts with vehicular traffic.

Bike Access is assumed at all transit stations, with spaces for a minimum eight bicycles, if possible. From a design standpoint, auto access is not promoted, but is not discouraged in considering light rail station design as long as it does not interfere with any other modes.

Comments: The placement of bus ahead of walk and bike access modes, demonstrates the recognition that bus access is critical and making transfers as easy as possible benefits the overall transit system.

This document addresses design criteria *within* the station itself, not modes of access *to* the station. Additional follow-up with TriMet may reveal internal documents that discuss the criteria for establishing bus transfer and park and ride access.

Bay Area Rapid Transit Planning Department, *16th and Mission BART Station Access Plan*, 2002

Applicable Guidebook Sections:

- Factors that affect access decisions
- Decision-making framework
- Case study

Line-Haul Mode(s) Considered:

☐ Commuter Rail ☒ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☒ Bike ☒ Pedestrian

Summary: This Station Access Plan for the Bay Area Rapid Transit (BART) subway station at 16th and Mission represents a joint effort between the BART Planning Department and the community. The community initially identified three key recommendations to the Planning Department, which were:

- Increase accessibility and choices;
- Improve visibility and connectivity; and
- Encourage a diverse range of activities and people on the plazas.

Visibility and accessibility were addressed by the Design Plan first by removing many of the visual and physical barriers that gave the plazas a fortress-like quality and made pedestrian circulation difficult. The community also gave specific physical recommendations in the Design Plan, including:

- Increased usable plaza area
- Bus bulbs
- Bus canopies
- Public art
- Bicycle storage
- Community information board
- Improved circulation through the plaza and to the neighborhood

The Station Access Plan was written in response to peak period access constraints at home-origin BART stations. BART identified ideal access targets that include a reduction in the share of single-occupancy auto with corresponding increases in walking, biking, carpool, passenger drop-off and taxi modes.

Upon reviewing the station and its surroundings, the plan identified recommendations for each access mode. The 16th and Mission station experiences a "walk" mode split that was more than three times greater than the system average, and it is therefore a high priority. Key recommendations for the pedestrian access include:

- Create a safe and inviting environment on the Station Plazas and near the Station;
- Encourage programmed activity in Station Plazas such as vendors, rotational exhibits, or activities associated with neighborhood non-profit organizations;
- Provide a sheltered waiting area with seating;
- Provide wayfinding signage within the station and the station area;
- Provide late-night BART service for patrons and employees of late night entertainment establishments; and
- Encourage development of pedestrian friendly, mixed-use development in station area.

Bicycle mode share at 16th and Mission is also higher than the systemwide average reflecting the existence of bicycle storage facilities located within the paid area; the number of younger, lower income area residents, and proximity to the very successful bike lanes constructed on Valencie Street in recent years. Key recommendations include:

- Provide for additional safe and secure bicycle storage at the station to meet demand;
- Provide stair channels between the street and platform to accommodate movement of bicycles;
- Explore the feasibility of reducing the restrictions of bicycles on trains, particularly southbound to the Millbrae connection to Caltrain;
- Explore the feasibility of a bicycle station on one of the plazas or in the station area; and,
- Work with the city to improve bicycle lane infrastructure and wayfinding signage for bike lanes to and from BART.

The share of transit users at the station who access by transit is actually one-third lower than the systemwide average, possibly due to nighttime safety concerns and the availability of other options for accessing BART. Key transit recommendations include:

- Complete plaza improvements to improve safety and provide patron amenities;
- Provide sheltered waiting areas with seating for transit users;
- Expand NextBus technology to additional routes serving the station;
- Update BART's brochures to reflect changes in MUNI service and routes;
- Encourage the implementation of MUNI's X-Plan to establish rapid transit corridors and improve service reliability; and
- Explore the need for and feasibility of shuttles to serve employers in Mission Bay South and other new development in the area, in conjunction with MUNI representatives.

Since there is no parking at the 16th and Mission Station, auto constitutes a small portion of transit riders' access mode. Key recommendations to improve access for autos include signage and a new drop-off area.

Fort Worth Transportation Authority, *Southwest-to-Northeast Rail Corridor–Station Planning Process & Guidelines*, 2007

Applicable Guidebook Sections:

- Factors that affect access decisions
- Case Study

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☐ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☒ Bike ☒ Pedestrian

Summary: This document provides planning process and guidelines for rail station site selection as part of a new rail corridor planning project in Fort Worth, Texas. Access issues presented through key criteria for station locations and station types, and how each of these elements meet three goals: promoting community relationships, enhancing mobility options, and creating sustainability through good design. Criteria include:

1. Neighborhood compatibility
2. Ridership projections
3. Station spacing
4. Station layout and parking
5. Vehicle accessibility and connections
6. Bicycle and pedestrian accessibility
7. Natural environment
8. Planned environment

The planning process for environmental impact statement is summarized at three levels:

1. Stations location analysis
2. Station area planning
3. Transit-oriented development analysis

Evaluation tools outlined include goal-setting and criteria developed to measure how well station locations and designs meet these goals. Guidelines for design include conceptual station locations and a range of station types: regional, community, neighborhood, downtown, and main street. Station design features are also explained and pictured, including platform arrangements, plaza designs, and modal access facilities

Daley, *Wareham Intermodal Transportation Center Site Analysis*, 2005

Applicable Guidebook Sections:

- Evaluation Tools
- Decision-making framework
- Case Study

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☐ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☐ Auto ☒ Transit ☒ Bike ☒ Pedestrian

Summary: Current access issues at the Wareham Intermodal Transportation Center relate to inadequate facilities for bus stops and transfers. Site analysis was conducted to determine if improvement of transfer facilities (intermodal center) would be expected to encourage greater transit ridership and support local economic development.

A survey was conducted via the town website to gauge public support for an intermodal center, identify the primary features necessary for the facility, and solicit additional comments. A second survey of commuter bus riders also asked about preferences for locations and amenities.

Intermodal Committee Meetings allowed a study advisory board to guide the site selection process and provide a final recommendation. Evaluation tools included two survey efforts and a stakeholder/public involvement process that included local elected officials, the Southeastern Community & Economic Development Authority, police, Senior & Social Services, Disability Commission, West Wareham Strategic Planning Commission, Cape Cod Canal Region Chamber of Commerce, GATRA, etc. This allowed regional provider Greater Attleboro Taunton Regional Transit Authority (GATRA) to move forward with its planning process and solicit federal funding.

Denton County Transportation Authority, *Station Operations, & Bicycle Facilities Planning Guidelines*, 2006

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Factors that affect access decisions
- Evaluation tools

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☐ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☒ Bike ☒ Pedestrian

Summary: This document provides planning process and guidelines for rail station design, maintenance facilities, and bicycle and pedestrian access as part of a new rail corridor planning project (environmental impact statement) in Denton County, Texas.

Access issues presented through key criteria for station locations and station types, and how each of these elements meet three goals: promoting community relationships, enhancing mobility options, and creating sustainability through good design. Criteria include:

1. Neighborhood compatibility
2. Ridership projections
3. Station spacing
4. Station layout and parking
5. Vehicle accessibility and connections
6. Bicycle and pedestrian accessibility
7. Natural environment
8. Planned environment

The document summarizes the planning process at three levels for environmental impact statement:

1. Stations location analysis
2. Station area planning
3. Transit-oriented development analysis

Evaluation tools outlined include goal-setting and criteria developed to measure how well station locations and designs meet these goals. Guidelines for design include conceptual station locations and a range of station types: regional, community, neighborhood, downtown, and main street.

Station design features are also explained and pictured, including platform arrangements, plaza designs, and modal access facilities for each station type. Bicycle facility design included extra detail on adapting a rail trail through the reconstruction of an active commuter rail alignment with the bicycle trail adjacent. Specific bicycle and pedestrian facility and access criteria are included for the new rail project.

Sonoma-Marin Area Rail Transit (SMART), *White Paper No. 12 – SMART Station Planning*, 2008

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Evaluation tools
- Decision-making framework

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☐ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☒ Bike ☒ Pedestrian

Summary: This document describes 14 proposed station locations and design considerations for a planned 70-mile rail corridor in Sonoma and Marin Counties, California. Station plans focus on an effort to create multi-modal centers to connect rail service with buses, shuttles, and taxis along with improved bicycle and pedestrian access.

Station location selection was based on a review of planning documents, existing transit facilities, land availability, and stakeholder involvement. Parking will be available at most- but not all-stations, indicating a need to prioritize other access modes in order to maximize ridership.

INTERNATIONAL

Banister, Pucher, and Lee-Gosselin, *Making Sustainable Transport Politically and Publicly Acceptable*, 2007

Applicable Guidebook Sections:

- Decision-making framework

Line-Haul Mode(s) Considered:

☐ Commuter Rail ☐ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☐ Auto ☐ Transit ☐ Bike ☐ Pedestrian

Summary: This paper provides an overview of the public and political landscape as it relates to sustainable transportation policy in Europe, the U.S., and Canada. Specific line-haul and access modes are not discussed individually in this document. Rather, the authors describe existing attitudes and perspectives around the world. They conclude that Europe has been most successful advancing policies that support sustainable transportation, whereas the U.S. and Canada face stronger opposition. The U.S., in particular, has been less able to advance any policy that would restrict driving or make it more expensive.

Since political acceptability is driven by public opinion, the authors sought to determine whether sufficient public support for change exists. Sustainable transportation needs to be seen by the public as being of sufficient importance, and a proposed policy package must be seen to actually deliver the desired outcomes. Therefore, the authors advocate small, incremental changes that can be used to build up acceptability.

The authors identify four Principles of Acceptability, which outline four separate sets of policy measures aimed at achieving sustainable transportation. They include:

a) Technology, including investment in technology in transportation modes, information systems, and in the transportation system itself, and in giving industry clear directions on priorities (e.g. on hybrid and fuel efficient vehicles and alternative fuels);
b) User regulation, including driver and vehicle licensing, taxation and pricing, standards and traffic regulations;
c) Land use development, including planning and regulation; and
d) Information, including social pressure, awareness raising, demonstration, persuasion, and individual marketing.

This leads to the discussion of acceptability, for which the authors also identify seven key principles, which are summarized below.

1. *Information* – Explain the need for sustainable transportation policies through education, awareness campaigns, and prompting through media and social pressure.
2. *Involvement* – Gain public support and understanding (buy-in) through communication and involvement between all stakeholders.
3. *Packaging* – Combine measures to demonstrate push and pull relationship of policies (e.g., policies restricting car use should be accompanied by well publicized programs to improve alternatives such as driving alone, including car pooling, public transportation, cycling, and walking).
4. *Selling the Benefits* – Widely publicize benefits associated with sustainable transportation measures which have costs, inconvenience, and sacrifice.
5. *Adopt controversial policies in stages* – Allow support to be built up in terms of positive outcomes and measureable improvements in quality of life.
6. *Consistency and Longer Term Perspectives* – Long-term measures, such as pricing, should be implemented now, even though impacts might be slow in the initial stages.

7. *Adaptability* – Decisions today should not unnecessarily restrict the scope for future decisions. Piece-meal changes that allow for testing solutions may be more effective where impacts are unknown.

Individual's behavior changes continuously in response to policy measures, but also to changing personal circumstances, location, and life cycle changes. There is a need to engage with people through debate, and discussion is crucial to convincing them of the legitimacy and fairness of behavioral change. Through these methods, public and political acceptability of sustainable transportation can be increased.

Comments: The article is useful for thinking about policy and process that can lead to success, but does not address specific access issues.

Pucher, *Urban transport in Germany: providing feasible alternatives to the car*, 1998

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Factors that affect access decisions
- Case study

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☒ Heavy Rail/Subway ☒ Light Rail

☒ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☒ Bike ☒ Pedestrian

Summary: Pucher reviews the German experience of coordinated land use and transportation planning, which has witnessed declining mode shares for autos in many of its cities despite having the 2nd highest levels of auto ownership in the world. These successes are owed to land use planning (Germany has the third highest population density in Europe) and integrated urban transportation policies. The article studies three cities as successful examples (Münster, Freiberg, and Munich) and one unsuccessful example (Rhine-Ruhr).

Although development is spreading out into the countryside, suburban development in Germany is a much higher density than American cities. Development remains relatively compact, and the monocentric orientation toward the main city center continues to dominate. Still, these suburban developments have been more difficult to serve with transit. Connections to the central city are often easily accommodated with the suburban rail system, but cross-suburban service is almost nonexistent. Therefore, most growth in automobile travel demand is for suburban-oriented trips.

Rail transit is the backbone of the transit systems in many of the largest German cities, and has been the focus of national efforts to improve the public transit system overall. Moreover, virtually every rail system in Germany has been expanding its park-and-ride facilities to attract riders

living in low-density areas. They have also begun to provide bike-and-ride facilities and improve pedestrian access to bus stops and rail stations.

Comments: The German experience demonstrates that it is possible to reduce auto travel by limiting its use in central cities and providing travelers with attractive alternative transportation modes. Münster, Freiberg, and Munich have accomplished this by offering cheaper and better public transportation services, extensive bikeway systems, large car-free zones, and priority rights-of-way and traffic signalization for bicycles, buses, and trams.

Although the article is 10 years old, it describes helpful steps taken in Germany to augment the transportation system. Unfortunately, the article only tangentially discusses access, indicating that attention to it has helped the system.

Glotz-Richter, *Moving the City: A Guided Tour of the Transport Integration Strategy in Bremen, Germany*, 2003

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Factors that affect access decisions
- Case study

Line-Haul Mode(s) Considered:

☐ Commuter Rail ☐ Heavy Rail/Subway ☒ Light Rail

☒ Bus Rapid Transit ☒ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☒ Bike ☒ Pedestrian

Summary: Glotz-Richter provides a tour of Bremen's transportation system, discussing system integration and intelligent transportation systems in place. Bremen has successfully encouraged non-auto modes (less than 40-percent drive alone mode split). The experience in Bremen has focused on making the transportation experience for the user as easy as possible. The 35 transit operators in the region fall under one umbrella organization which means users need one ticket, one tax, and one information system for rail, tram, buses, and more. Transit stations also provide real-time information for passengers. Finally, connections with other modes, such as biking and walking are well-thought, and include guarded storage units and services such as bike repair, bike rental, and bike wash.

Comments: Bremen's experience highlights the benefits of comprehensive modal planning to create a seamless system for users.

Evaluation Tools

The literature review identified many evaluation tools applicable to transit access planning. Some of these tools were developed with transit access specifically in mind, while others were developed for other applications but can be applied to specific aspects of transit access.

There is considerable research on access mode choice, which shows that individual characteristics as well as built environment characteristics are important. Both aggregate and disaggregate models have been developed, based on data availability. Transit agencies may use these models to estimate access mode shares under proposed development or improvement scenarios.

Willson and Menotti (2007) also provide an evaluation tool to assess ridership and financial impacts of development scenarios to trade-off the impacts of new development versus lost parking spaces. Other ridership tools, such as Kuby, et. al. (2004) are also available to estimate ridership based on a wide range of factors that include access variables. Note that this research shows that newer light-rail systems in polycentric urban areas are not necessarily oriented toward CBD trips, further supporting the need to plan suburban station areas to accommodate both access and egress trips.

There are also several evaluation tools to describe the quality of pedestrian and bicycle facilities. These tools can be used to identify specific deficiencies and needed improvements to increase non-motorized access. Similarly, the *Transit Capacity and Quality of Service Manual* provides tools to assess the quality of transit facilities from the passenger perspective.

TRANSIT PERFORMANCE

Kittelson & Associates, Inc., Urbitran, Inc., LKC Consulting Services, Inc., MORPACE International, Inc., Queensland University of Technology, and Nakanishi, *TCRP Report 88: A Guidebook for Developing a Transit Performance-Measurement System*, 2003

Applicable Guidebook Sections:

- Factors that affect access decisions
- Evaluation tools

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☒ Heavy Rail/Subway ☒ Light Rail

☒ Bus Rapid Transit ☒ Commuter Express Bus ☒ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☒ Bike ☒ Pedestrian

Summary: This guidebook describes evaluation tools (performance measures) that are potentially relevant to TCRP B-38. The interactive menus used to identify performance measures for a specific application may also suggest a potential decision-making framework for the guidebook produced as a result of TCRP B-38.

This guidebook is intended to help transit agency staff develop a performance measurement system. The guidebook describes the benefits of performance measurement, provides a process for implementing a performance measurement system, describes case studies, describes the characteristics of an effective performance measurement system, and categorizes and critiques more than 400 performance measures. The categories of performance measures that are most relevant to TCRP B-38 are the following:

- Availability (Stop Accessibility, Stop Spacing, Transit Accessibility Index)
- Community (Accessibility, Service Equity, Community Cohesion, Community Economic Impact, Personal Economic Impact, Employment Impact, Property Value Impact, Land Development Impact, Environmental Impact, Visual Impact)
- Travel Time (Transfer Time, Delay)
- Safety and Security (Number of Crimes, Number of Incidents of Vandalism)
- Capacity (Person Capacity, Station Element Capacity)

Stop-level performance measures are generally more relevant to TCRP B-38 than route- and system-level performance measures.

Kittelson & Associates, Inc., KFH Group, Inc., Parsons Brinckerhoff Quade & Douglass, Inc., and Hunter-Zaworski, *TCRP Report 100: Transit Capacity & Quality of Service Manual*, 2003

Applicable Guidebook Sections:

- Evaluation tools

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☒ Heavy Rail/Subway ☒ Light Rail

☒ Bus Rapid Transit ☒ Commuter Express Bus ☒ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☒ Bike ☒ Pedestrian

Summary: This manual provides evaluation tools for assessing transit capacity and quality of service for a wide range of transit modes. The manual describes basic concepts associated with transit capacity and transit quality of service. It identifies several transit quality of service measures and assigns Level of Service (LOS) thresholds to recommended measures as part of a quality of service framework. Passenger access to stops is identified as a factor that influences transit capacity.

Part 3 of the manual discusses station access as part of transit service coverage. It describes walk-access distance, street connectivity, bicycle-access distance, bicycle storage at stations and on-board transit vehicles, the roadway environments in which pedestrians and bicyclists must travel to reach transit, characteristics of park-and-ride users, types of park-and-ride facilities, and market areas for park-and-ride lots (i.e., "catchment areas").

The manual includes a very detailed description of terminal capacity and passenger circulation concepts. It addresses elevators, escalators, gangways (for ferries), stairways, doorways, walkways, ramps, fare gates and barriers, station-area wayfinding, passenger flow diagrams (which may include parking lots and fare payment areas), emergency evacuation, and passenger queuing. It also describes procedures that can be used to calculate the passenger capacity of stops, stations, transit centers, and intermodal terminals.

Finally, the manual addresses modes that are more uncommon in the U.S., including aerial tramways and funiculars, which may have unique access needs and constraints.

Comments: Knowing the passenger capacity of transit system elements could allow for better planning of station access (e.g., a more accurate estimate of the number of parking spaces needed at a station).

The manual discusses some station access issues: the proximity of transit to a traveler's origin and destination, door-to-door travel times, and the safety and security of walking to and from transit stops. However, the recommended service coverage measure in the quality of service framework does not address station access modes.

Kuby, Barranda and Upchurch, *Factors influencing light-rail station boardings in the United States*, 2004

Applicable Guidebook Sections:

- Factors that affect access decisions
- Evaluation tools

Line-Haul Mode(s) Considered:

☐ Commuter Rail ☐ Heavy Rail/Subway ☒ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☒ Bike ☒ Pedestrian

Summary: This paper describes the results of a model to estimate light-rail station boardings based on station-area and regional characteristics. The model estimation uses multivariate linear regression, and tests the effects of 17 independent variables in five categories: 1) traffic

generation; 2) intermodal connection; 3) regional; 4) network structure; and 5) socioeconomic. The model was estimated using data for 268 light-rail stations in nine American cities.

The results of the modeling showed that the socioeconomic characteristics and network structure were the primary determinants of ridership. However, several access-related factors were also determined to have significant effects on stations boardings. Specifically, both the amount of parking provided and the number of available bus connections were positively associated with increased ridership.

The model results also showed no significant impact on ridership for stations located the CBDs, after accounting for other factors. This result indicates that light-rail systems are effectively capturing riders for suburban activity centers as well as downtowns.

Comments: The model results that increasing parking and bus connections results in increased ridership is unsurprising, but important nonetheless. The linear regression coefficients provide a simple method to estimate the impact to ridership for alternative station development scenarios. For instance, the ridership coefficients for parking spaces and residents are 0.77 and 0.09, respectively. This indicates that a ridership-neutral TOD strategy would require 8.5 new residents for every lost parking space.

The result that CBDs are no more likely to generate ridership than other stations, considering other factors, indicates that planning for station access in polycentric metropolitan areas should consider stations as both origins and destinations.

The rider survey found that a mean walking distance for riders of 0.5 miles, and over 30% of riders walked farther than 0.5 miles. This indicates a need to think beyond the traditional 0.5 mile radius for pedestrian access for some high-quality transit services.

PARK & RIDE

Willson and Menotti, *Commuter Parking Versus Transit-Oriented Development: Evaluation Methodology*, 2007

Applicable Guidebook Sections:

- Evaluation tools
- Decision-making framework
- Case study

Line-Haul Mode(s) Considered:

☐ Commuter Rail	☒ Heavy Rail/Subway	☐ Light Rail
☐ Bus Rapid Transit	☐ Commuter Express Bus	☐ Ferries

Access Modes Considered:

☒ Auto ☐ Transit ☐ Bike ☒ Pedestrian

Summary: This paper presents a method for testing the impacts of alternative station development scenarios, with an emphasis on assessing the trade-offs associated with providing commuter parking versus encouraging transit-oriented development. The model was developed by BART for planning applications, to develop an objective method for considering impact of lost parking capacity through transit-oriented development in BART station areas.

The model assesses both the impact of the development scenario on transit ridership and the financial impact to BART. Ridership impacts include both lost riders from reduced parking and new riders gained through transit-oriented development. Financial impacts include changes in parking revenue and the ability of new development to pay for itself through rent. Thirteen total model inputs are used, including current access mode shares, parking costs, elasticities, and land values. The model was created as a spreadsheet-based methodology.

The paper concludes with a case study where the model is used to assess the impacts of three alternative development scenarios at the MacArthur BART Station:

- Medium-intensity development with full replacement parking
- Medium-intensity development with partial replacement parking
- High-intensity development with partial replacement parking

The results of the case study showed that the high-intensity development had the largest increase in ridership and the largest increase in net revenues. The increase in revenues occurred despite the need for BART financing of improved non-auto access (e.g. feeder buses and pedestrian improvements) through increased ground rent and fare revenue. Requiring full replacement parking had the least financial benefit, as the model projected that ground rents would be unable to cover the cost of the project (i.e. financing would require public subsidy).

Comments: The methodology presented in this paper is unique amongst the literature in the comprehensiveness of the model that is presented. The users and/or developers of this model should be targeted for stakeholder interviews, and the use of this model by BART for real-world applications may be useful as a case study.

PEDESTRIAN AND BICYCLE

Richard Dowling, David Reinke, Aimee Flannery, Paul Ryus, Mark Vandehey, Theo Petritsch, Bruce Landis, Nagui Rouphail, James Bonneson, *NCHRP Report 616: Multimodal Level of Service Analysis for Urban Streets*, 2008

Applicable Guidebook Sections:

- Evaluation Tools

Line-Haul Mode(s) Considered:

☐ Commuter Rail ☐ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☐ Auto ☐ Transit ☒ Bike ☒ Pedestrian

Summary: This report offers a systematic approach to assessing pedestrian and bicycle level of service for urban street segments. It is intended to be used as a tool to evaluate the tradeoffs of various street designs in terms of their effects on the auto driver, transit passenger, bicyclist, and pedestrian perceptions of the quality of service provided by the street. The data required by the method include geometric cross-section, signal-timing, the posted speed limit, bus headways, traffic volumes,, transit patronage, and pedestrian volumes.

The method enables agencies to balance the level of service needs of auto drivers, transit riders, bicycle riders, and pedestrians in their street designs by providing agencies with a tool for testing different allocations of scarce street right-of-way to the difference modes using the street.

The team developed the methodology by showing video clips of various facilities to study participants, and asking them to rate the facilities from the perspective of difference user groups. The results of the survey were then used to calibrate a model consisting of objective variables related to roadway design and operation.

In developing the Integrated LOS model the researchers identified 37 variables to predict the perceived degree of satisfaction experienced by travelers on the urban street. These variables consist of four basic types: facility design, facility control, transit service characteristics, and the volume of vehicle traffic on the facility. Variables found to be significantly related to the perceived quality of pedestrian and bicycle environments: traffic volume, traffic speed, and the availability/width of pedestrian and bicycle facilities.

The models enable analysts to test the tradeoffs of various allocations of the urban street cross section among autos, buses, bicycles, and pedestrians. For example, the analyst can test the effects of reducing a four-lane street to three lanes and using the width saved to provide bicycle lanes

and a landscaped strip between the sidewalk and the street. The method also enables the analyst to compute the before and after levels of service for auto, bus, bicycle, and pedestrians.

Comments: This resource can be helpful in transit access planning in a number of ways, by allowing agencies to evaluate existing pedestrian and bicycle facilities, and assess the impacts of proposed changes. It also includes the outcomes of the studies that the researchers reviewed as well as outcomes from their own field data collection.

For professionals, the report is detailed and reads almost like a manual. Every step is documented, and the method and intentions are explained. However the technical nature of the report may make it more difficult for transit agencies to apply the methodology. Also, while the report provides some conclusions, it is more focused on the data collection and model calibration than interpreting the results.

The report is also unique in that it looks at each mode's different LOS models and makes a recommendation for which one to use. Furthermore Chapter 9 takes each recommended LOS model and combines them to create an integrated model that shows the overlap and conflicts of all of the modes' LOS models. The integrated model compares and contrasts each mode in a matrix showing the overlap in characteristics and data that is necessary.

Schwartz, Porter, Payne, Suhrbier, Moe, and Wilkinson, *Guidebook on Methods to Estimate Non-motorized Travel*, 1999

Applicable Guidebook Sections:

Evaluation Tools

Case Study

Line-Haul Mode(s) Considered:

☐ Commuter Rail ☐ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☐ Auto ☐ Transit ☒ Bike ☒ Pedestrian

Summary: This resource focuses on policies for local and regional planners rather than design of pedestrian facilities. It can help planners decide whether or not to improve their pedestrian and bicycle networks by describing and evaluating various methods for estimating demand and other forecasting strategies. The document does not link the specific methods described with specific local conditions. While most of the focus in on- and off-road facilities, the evaluation methods described can be applied to transit access facilities.

The report identified 12 methods for demand estimation, falling into four main categories:

- Demand Estimation

    - Comparison studies
    - Aggregate behavior studies
    - Sketch plan methods
    - Discrete choice methods
    - Regional travel models
- Relative demand potential
    - Market analysis
    - Facility demand potential
- Supply quality analysis
    - Bicycle and pedestrian compatibility measures
    - Environment factors
- Supporting Tools and Techniques
    - Geographic information systems (GIS)
    - Preference surveys
    - Latent Demand Score (LDS) method provides a way to estimate the level of travel that would occur if a bicycle facility (such as a paved shoulder or bicycle lane existed

For each analysis method, applied examples from the United States are provided.

Ayvalik and Khisty, *Heuristic Analysis of Impacts of Commuter Rail Station Consolidation on Pedestrian Access*, 2002

Applicable Guidebook Sections:

- Evaluation tools
- Case study

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☐ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☐ Auto ☐ Transit ☐ Bike ☒ Pedestrian

Summary: This paper describes the results of a case study conducted on the Milwaukee North Metra line in Chicago to assess the impacts of station consolidation to pedestrian access. The case study looked at the potential to consolidate the Mayfair and Grayland stations, which are located approximately 1 mile apart, into a single central station. While this consolidation would save approximately 2 minutes of average travel time, nearly 60% of passengers access the station by walking, indicating a need to consider pedestrian access as well.

The paper presents a heuristic method for estimating the effects of the consolidation on walking distance using the results of a rider survey. The results found that 72% of passengers would face longer walking distances with a consolidated station, and that the average increase would be 1.4

blocks (approximately 900 feet). Based on current walking distances, passengers accessing the consolidated station by foot was projected to decrease 27% compared to current boardings.

Comments: The paper does not provide a recommended course of action; rather, it simply provides a method for assessing impacts. The actual decision to consolidate the station would require weighing the impacts to pedestrian access against operating cost savings and new ridership attracted by the reduced travel time.

MODE CHOICE MODELING

Park and Kang, *Factors that Influence Walking and Biking to the Station: Modeling Commuter Rail Users' Access Mode Choice*, 2008

Applicable Guidebook Sections:

- Factors that affect access decisions
- Evaluation tools

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☐ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☐ Transit ☒ Bike ☒ Pedestrian

Summary: This paper presents the results of a model estimation for access mode choice to the Mountain View, California Caltrain commuter rail station. Two binomial logit models were estimated, one for Auto vs. Walk access and the other for Auto vs. Bike access. Data for the model were collected through a mail-in survey of 770 passengers distributed to passengers at the station. The station had mode splits of 17% and 11% for walk and bike, respectively, providing sufficient data to estimate statistically significant models.

The results of the models showed that several individual characteristics are significant in the choice of access mode for commuter rail. In particular, the propensity to walk or bike decreased with trip distance and auto availability. The decision to bike was significantly influenced by race and gender, with whites and males more likely to choose biking. Because the models were estimated using data from only one station, neighborhood-level characteristics had little effect on access mode. However, intersection density in the immediate vicinity of the trip origin was positively associated with the choice to walk, while high-volume roadways were negatively associated with both the choice to walk and bike.

The results of the survey are also interesting for the results showing access distance by mode. At distances of less than 0.5 miles, walk trips dominated access. Auto access reached 50% at approximately 0.75 miles and accounted for over 90% of access trips at distances over 2 miles. Bicycle access peaked at distances between 1 and 1.25 miles.

Comments: It is unclear why the authors estimated two separate mode choice models (Auto vs. Bike, Auto vs. Walk) rather than a single model encompassing all 3 modes. Also, because the model was estimated for trips at only one station, it is unable to assess the impacts of land-use, design, and parking supply on the decision to access transit by driving.

Kim, Ulfarsson and Hennessy, *Analysis of light rail rider travel behavior: Impacts of individual, built environment, and crime characteristics on transit access*, 2007

Applicable Guidebook Sections:

- Factors that affect access decisions
- Evaluation tools

Line-Haul Mode(s) Considered:

☐ Commuter Rail ☐ Heavy Rail/Subway ☒ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered: Auto, Transit, Pedestrian

☒ Auto ☒ Transit ☐ Bike ☒ Pedestrian

Summary: This paper presents a model to estimate access mode choice for light rail riders, using a survey of 407 riders of the St. Louis MetroLink system conducted in 2002. Using the survey results, a disaggregate multinomial logit model was estimated with four potential mode choices: drive, pick-up/drop-off, bus, and walk. Survey data were collected on many individual characteristics, and origin station information was used to determine station area characteristics for each user.

The model results showed that both individual and station characteristics are significant in determining access mode choice. Significant individual characteristics include the following:

- *Age* – increasing age decreases the likelihood of walking to the station
- *Gender* – Females are more sensitive to crime levels and time-of-day. Females traveling after 7pm or to stations with higher crime levels are more likely to be picked-up compared to walking or taking the bus.
- *Race* – African-Americans are more likely to take the bus versus walking
- *Vehicle availability* – Travel with vehicles available are much more likely to drive to the station versus use any other access mode.

Several station-area characteristics were also significant in access mode choice. As with the other model evaluated as part of this literature review, increasing distance reducing the likelihood of

walking. Conversely, higher crime levels at the station reducing the likelihood of either walking or taking the bus for females.

Comments: Unfortunately, variables reflecting the quality of the pedestrian environment (e.g. sidewalks, traffic volumes, intersection density) were not tested, so there is no indication of the roles these variables play. Bicycle access was excluded from the modeling due to a lack of data (i.e. the survey did not detect sufficient cyclists to produce statistically significant results).

The finding that crime is a significant determinant in access mode choice is important, as it implies that improved safety and/or safety perception at stations may increase ridership.

Cervero, *Walk-and-Ride: Factors Influencing Pedestrian Access to Transit*, 2001

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Factors that affect access decisions
- Evaluation tools

Line-Haul Mode(s) Considered:

☐ Commuter Rail ☒ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered: Pedestrian

☐ Auto ☐ Transit ☐ Bike ☒ Pedestrian

Summary: This paper presents research conducted to assess factors that impact the choice to access transit via walking. Two separate datasets are used to draw conclusions: an aggregate analysis of BART access trips in the San Francisco Bay Area, and a disaggregate analysis of access trips the Washington Metrorail from origins in Montgomery County, Maryland. Models are estimated for each dataset, and mid-point elasticities for key variables are provided. The BART analysis uses regression analysis to predict the percentage of walk access and egress trips, while the Montgomery County analysis uses a binomial logit model to predict the probability that an individual chooses to access transit by walking.

The results of the BART analysis indicate that provision of parking spaces and bus connections reduce the percent of walk access trips to a given station, even after accounting for density and land use mix. Both residential and employment densities surrounding the station were also highly correlated with walk trips. Finally, land use diversity was also associated with higher levels of walking, indicating that the quality and vibrancy of the pedestrian environment may impact walking mode share.

The disaggregate analysis for Montgomery County Metro riders indicates a strong relationship between urban design variables and the individual choice to walk to the station. Land use

diversity, provision of sidewalks, and intersection density were all correlated with the choice to walk. Shorter walk times were also highly correlated with the decision to walk. In the disaggregate model, density was not a factor in the choice to walk to the station, indicating that in aggregate models density is simply a proxy for the number of people living within easy walking distance.

Comments: The findings that urban design is strongly correlated with the decision to access transit by walking indicate that improving station area design to make it more pedestrian friendly has the potential to significantly increase walk access trips. Thus, better pedestrian facilities may provide a relatively cheap method of increasing ridership, compared to increasing parking supply or transit feeder service.

Interestingly, results of the BART survey showed that walking was the primary access mode for trips up to 5/8 of a mile, which is somewhat higher than the ½ typically cited in the literature for pedestrian trips.

Loutzenheiser, *Pedestrian access to transit: model of walk trips and their design and urban form determinants around Bay Area Rapid Transit stations*, 1997

Applicable Guidebook Sections:

- Factors that affect access decisions
- Evaluation tools

Line-Haul Mode(s) Considered:

☐ Commuter Rail ☒ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☐ Bike ☒ Pedestrian

Summary: Loutzenheiser conducted research on mode choice between home and repaid transit stations of the BART system. Using the same 1992 BART survey used by Cervero (2001), Loutzenheiser tried to find determinants for walking trips to the station, by combining individuals' socio-economic characteristics and aggregated station area characteristics in his model. First, Loutzenheiser conducted a logit analysis with disaggregated travel and socio-economic data from survey respondents. His model found that walking distance, car availability, and gender were the significant determinants of choice to walk to the station.

Like Cervero (2001), his second model used a linear regression analysis with mode share by station as a dependent variable and with station-level aggregated built environment and socioeconomic data for the independent variables. His second analysis at the station-level found that density, number of parking spaces, and distance to the nearest retail center were significant determinants for walking trips to the station.

Finally he created a third model joining the aggregated station area characteristics data with the individual socio-economic data. He found that disaggregated socio-economic variables dominantly entered the model, and the aggregated built environment variables were left out. After controlling for the socio-economic variables, Loutzenheiser's study managed to find that substantial parking space at the station was major deterrents to walking, while retail around the station encouraged walking

INTERNATIONAL

Moshe and Rietveld, *The access journey to the railway station and its role in passengers' satisfaction with rail travel*, 2007

Applicable Guidebook Sections:

- Factors that affect access decisions
- Evaluation tools

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☐ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☒ Bike ☒ Pedestrian

Summary: This paper describes the results of a Dutch Railways passenger satisfaction survey to determine factors that influence access mode choice, and satisfaction with rail access. While the study focused on passengers use intercity rail, the survey indicated that the majority of customers use the rail system for commuting to work and school, indicating that the results may be applicable to commuter rail in the United States.

The results of the survey showed that less than 15% of passengers use automobiles as their primary access, with less than 10% driving when the access journey is less than 3 km. As may be expected for a country with the highest bicycle mode share in the Europe (27%), bicycles play a major role in rail access, with almost 40% of all access trips being taken by bicycle. Moreover, the share of bicycling has risen over the past 2 decades even as Dutch auto ownership has increased considerably. In fact, only 16% of Dutch passengers with automobiles available, chose to use them to access transit.

The results of the survey were also used to model the extent to which the quality of the access journey plays into the perception of the overall rail trip. The resulting linear regression model shows that access journey has a modest, but significant effect on passenger perceptions. In particular, parking capacity, public transit connections, and perception of the station were found significant. The results indicate that improved station access is a feasible method for transit

agencies to improve passenger satisfaction and ridership. This is important, as access improvements are often less costly than operational improvements.

Comments: While there are numerous reasons for the Dutch propensity to cycle that are not directly transferable to the United States, the results of the survey indicate that cycling can be a preferred option for transit access given the right set of policies and facilities (see Pucher 2007).

Debrezion, Pels, and Rietveld, *Modelling the Joint Access Mode and Railway Station Choice*, 2007

Applicable Guidebook Sections:

- Factors that affect access decisions
- Evaluation tools

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☐ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☒ Bike ☒ Pedestrian

Summary: The study develops an aggregate (post-code level) nested-logit model for both station choice and station access mode, using the results of a survey of Dutch rail passengers. In order to estimate the station choice model, the authors also developed a measure of "service-quality" for each stations, taking into account the amount and type of service provided at each station.

The results of the evaluation showed that most appropriate nesting structure was one in which passengers first pick the access mode, and secondly choose the particular departure station. The model showed that car ownership decreased the likelihood of using public transit, but did not affect the choice of whether to bike to the station. In fact, auto ownership actually increases the likelihood of biking, though the results are not significant. Station choice was heavily influenced by service quality, distance, and the provision of both auto and bike parking.

Comments: Due to the vastly different travel characteristics of the Dutch compared to American travelers, the model developed in this paper would not be directly transferable to an American context. However, the methodology used to develop the model is informative and shows the feasibility of developing access mode choice models.

Tsamboulas, *Golias and Vlahoyannis, Model development for metro station access mode choice*, 1992

Applicable Guidebook Sections:

- Factors that affect access decisions
- Evaluation tools

Line-Haul Mode(s) Considered:

☐ Commuter Rail ☒ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☐ Bike ☒ Pedestrian

Summary: This paper develops a disaggregate access mode choice model for the Athens Metro using the results of a survey of 1,200 transit users. The survey covered users of three stations, each of which had differing land use and transportation network characteristics. Four models were developed using a market segmentation approach that accounted for trip purpose and the availability of an automobile for the transit access trip.

The results of the model estimation showed that car ownership, travel time to the station, and the cost of parking/public transit all had significant influences on the choice of travel mode. The results also showed that women were somewhat less likely to walk and more likely to take public transit than men. For non-work trips, increasing age was associated with a higher likelihood of taking transit and lower likelihood of walking.

Comments: This paper provides an excellent example of how travel survey data can be used to develop a statistically significant disaggregate access mode choice model. However, many household travel surveys do not have sufficient data to estimate separate transit access mode choice models, as the number of transit users included in the surveys is so limited.

Transit-Oriented Development

Transit-Oriented Development (TOD) is the subject of a large body of research, policies, and case studies, of which a large portion is related to transit access. Overall, research shows that there are many instances of successful TOD in the United States occurring at both new and existing stations, and as both greenfield and redevelopment. The market for TOD, however, is still oriented toward residential and office development, with few examples of successful large-scale retail TOD.

Successful TOD can help transit agencies increase ridership while decreasing the cost of providing parking and/or feeder services. However, there are many elements that are required for TOD to occur. Most importantly, TOD is dependent on market forces, which may not always favor increasing density and reducing parking. Good design principles are required to insure that new development truly is oriented to transit, and not simply adjacent to transit. In addition, fostering TOD requires partnerships between public agencies and with private developers to overcome institutional barriers.

The review of experiences in both the United States and internationally indicate that TOD benefits from supporting policies at a state-wide and regional level as well as embrace of TOD principles at the local level.

RESEARCH

Institute of Urban and Regional Development (University of California at Berkeley), Parsons Brinckerhoff Quade & Douglas, Inc., Bay Area Economics, and Urban Land Institute, *TCRP Report 102: Transit Oriented Development in the United States – Experiences, Challgenges, and Prospects*, 2004

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Factors that affect access decisions
- Decision-making framework
- Case study

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☒ Heavy Rail/Subway ☒ Light Rail

☒ Bus Rapid Transit ☒ Commuter Express Bus ☒ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☒ Bike ☒ Pedestrian

Summary: This report describes TOD and joint development projects throughout the U.S. It provides case studies and identifies relevant factors and impacts. The report defines TOD and joint development, describes characteristics of TOD and joint development projects in the U.S., describes implementation tools (e.g., zoning) and funding options, assesses implementation challenges, identifies benefits, assesses ridership related to TOD and joint development, assesses impacts on real estate, and summarizes lessons learned from case studies. Surveys of transit agencies, developers, and lenders were conducted to compile the information presented.

TOD implementation tools relevant to TCRP B-38 include the following:

- Parking management (parking replacement policies, parking as an obstacle, automobile orientation, market demand)
- TOD overlay zones
- TOD densities and land uses
- TOD parking codes

TOD barriers relevant to TCRP B-38 include the following:

- Political barriers (e.g., public perception of increased densities)
- Parking standards
- Market demand
- Land values (before or after TOD implementation)
- Mix of residential and non-residential uses
- Multitude of stakeholders

Comments: This report presupposes a station area that does not rely on automobile access.

Transit Cooperative Research Program, *Transit-Oriented Development and Joint Development in the United States: A Literature Review*, 2002

Applicable Guidebook Sections:

- Description of access alternatives and access issues

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☒ Heavy Rail/Subway ☒ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☐ Auto ☐ Transit ☐ Bike ☒ Pedestrian

Summary: This TCRP document thoroughly reviews the available transit-oriented development literature. The review covers institutional questions, evaluation of impacts and benefits, implementation, and urban design – the latter relating to access issues.

Principles for achieving pedestrian-friendly designs are identified in the document, including:

- Create pedestrian streets that will primarily serve foot traffic and encourage bicycle travel.
- Orient buildings to the street with set backs of no more than 25 feet. Buildings placed close to a street minimize walking distances between destinations and also provides visual enclosure, an important element in creating a comfortable outdoor environment.
- Set minimum floor-area ratios (FARs) for retail and commercial uses to create a lively streetscape and minimize dead spaces created by parking lots.
- Use gridlike street patterns that allow many origins and destinations to be connected by foot; avoid cul-de-sacs, serpentine streets, and other curvilinear alignments that create circuitous walks and force buses to meander or retrace their paths
- Use traffic-calming measures such as narrow streets, on-street parking, vertical realignments (e.g., street tables), horizontal realignments (e.g., chicanes), and street trees
- Shorten trips through good site planning, using short blocks and straight streets, minimal building setbacks, and pedestrian shortcuts. To encourage walking, block lengths of 300 feet are suggested since smaller block faces allow for high levels of pedestrian connectivity.
- Provide a continuous network of sidewalks wide enough to accommodate anticipated levels of pedestrian traffic. Sidewalks should be located along or visible from all streets and allow comfortable, direct access to core commercial areas and transit stops.
- Ensure safe, convenient, and frequent street crossings. Signalized crossings, bulb-outs, and mid-block crossings are recommended
- Use landscaping, weather protection, public art, street furniture, lighting, public phones, and other provisions in public spaces. Likewise, require all developments to provide for pedestrian and cyclist needs, such as benches, continuous awnings, bicycle racks, and street trees.

TOD designers point out that such design elements cannot stand in isolation—indeed, they are co-dependent. Grid-iron streets of a superblock scale without continuous sidewalk networks, for example, are unlikely to entice many suburbanites to give up their cars. Collectively, transit-sensitive design elements can create fundamentally different milieus in and around transit stations that make transit riding a pleasant experience.

Comments: The document doesn't address access, per se, rather it identifies the qualities that make TOD successful – a component of which involves pedestrian amenities.

Evans, Pratt, Stryker, and Kuzmyak, *TCRP Report 95: Traveler Response to Transportation System Change, Chapter 19: Transit-Oriented Development*, 2007

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Factors that affect access decisions

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☒ Heavy Rail/Subway ☒ Light Rail

☒ Bus Rapid Transit ☒ Commuter Express Bus ☒ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☒ Bike ☒ Pedestrian

Summary: This report is one of 19 chapters in TCRP Report 95. It provides an evaluation tool (i.e., data) for assessing the impacts of transit-oriented development (TOD). Case studies are also included.

This report describes reasons for TOD, elements of TOD, types of TOD, methods of evaluating TOD and their limitations, and research findings related to traveler response to TOD. The report classifies traveler response to TOD along three dimensions: regional context (urban vs. suburban), land use mix (type and quantity), and primary transit mode. The report provides mode-specific discussions for heavy rail, light rail, commuter rail, BRT, and traditional bus.

TOD factors relevant to TCRP B-38 include the following:

- Walking distance to station
- Pedestrian-friendly design for walk access
- Demographics in station area (including automobile ownership)
- Highway access
- Parking demand and supply
- Inclusion of park-and-ride/pool
- Self-selection of residential TODs
- Impacts of TOD on the environment

Comments: This report presupposes a station area that does not rely on automobile access.

Two of the TOD factors identified above are particularly interesting with respect to TCRP B-38:

- Self-selection of residential TODs refers to the propensity of some individuals who are looking for housing to intentionally choose a residence due to its proximity to transit service. These individuals are more likely to walk to transit stations, and they may be more likely to not own an automobile. They are a specific station user type.

- The TOD environmental impacts factor suggests that environmental issues should be considered in siting stations and developing station access plans. If station access modes are primarily walking, bicycling, and feeder bus, vehicle-miles traveled and emissions may be more reduced on a per-user basis than a station for which driving is the primary access mode. This is not to say, however, that automobile-accessed stations do not result in environmental benefits.

Federal Transit Administration, *Station Area Planning: How to Make Great Transit-Oriented Places*, 2008

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Evaluation tools

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☒ Heavy Rail/Subway ☒ Light Rail

☒ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☒ Bike ☒ Pedestrian

Summary: Reconnecting America and the Center for Transit-Oriented Development developed this guidebook to promote best practices in TOD. The guidebook is intended to help with simplifying the complex decisions that surround planning for TOD projects and station areas by providing details about the scales of development likely to occur in different places, as well as station area planning principles and TOD plan checklists.

The guidebook identifies nine station area planning principles, several of which apply directly to access planning. The principles are:

- Maximize ridership through appropriate development
- Generate meaningful community involvement
- Design streets for all users
- Create opportunities for affordable and accessible living
- Make great public spaces
- Manage parking effectively
- Capture the value of transit
- Maximize neighborhood and station connectivity
- Implement the plan and evaluate its success

Designing streets for all users means that the streets surrounding transit stations need to support multiple transportation modes – automobiles, buses, pedestrians and bicyclists, taxis – and provide for the safety of all users. The guidebook identifies several opportunities to improve

street design, including TOD-specific street design standards; multimodal performance standards; and accommodation for bicyclists and pedestrians.

The goal of parking policies in the station area should be to minimize parking to the extent possible and maximize access for pedestrians and bicyclists and those who arrive at stations by bus or shuttle. Some policies and programs that support this goal include transit incentive programs, shared parking, car-sharing, TOD-friendly parking design, and transit overlay zones. It is important to provide bicycle parking commensurate with demand and use at a given station. Additionally, automobile parking should be located strategically in order to facilitate place making.

The walkability of the streets surrounding a transit station has a significant impact on whether people will choose to walk and ride transit, and the placement of intermodal facilities should not get in the way of walkability and place making. A strong pedestrian orientation, with adequate room for circulation, safe street crossing, an inviting station area, and amenities for transit users is important. Shorter blocks and more connected streets allow pedestrians, bicyclists, cars, and buses more travel options, thereby minimizing the distance and time spent getting to the station. In contrast, disconnected street patterns – where, for example, major arterials are served by cul-de-sacs – lengthen distance and time thereby discouraging transit use.

Finally, the guidebook lays out a process for evaluating the plan's success. Putting programs in place early to monitor the success of the plan, including before-and-after counts of pedestrian, bicycle, and vehicle trips, measures of economic activity, and benchmarks for housing production, all help ensure success by indicating whether follow-up actions are necessary. A program-level environmental review and fast-tracked development review, for example, can help facilitate implementation of a plan.

Dunphy, Myerson and Pawlukiewicz, *Ten Principles for Successful Development Around Transit*, 2003

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Factors that affect access decisions
- Decision-making framework

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☒ Heavy Rail/Subway ☒ Light Rail

☒ Bus Rapid Transit ☒ Commuter Express Bus ☒ Ferries

Access Modes Considered:

☒ Auto ☒Transit ☒ Bike ☒ Pedestrian

Summary: This document summarizes key principles related to successful TOD, and summarizes the potential to generate TOD for five key line-haul modes: commuter rail, heavy rail/subway, light rail, bus rapid transit, and express bus.

The authors conclude that heavy rail and light rail provide the greatest potential for TOD, due to their high capacity and ability to serve multiple trip types. As no new heavy rail systems are currently planned in the United States, this indicates that light rail will serve as the primary mode to generate TOD in metropolitan areas not currently served by heavy rail. Where commuter rail is expected to serve TOD, off-peak service should be considered to allow non-work transit trips. Finally, the potential for BRT to generate TOD in the United States is unclear, as there are few well-developed systems in place. It is noted that BRT has successfully generated development, however, in Curitiba, Brazil and Ottawa, Canada.

The main focus of the document is provision of a list of 10 factors that determine the success of TOD. These factors are listed below, with brief descriptions:

- *Develop a long-term vision* – Transit should be planned in accordance with the long-term vision of the community. Working together with multiple stakeholders at the outset to develop a clearly defined and realistic vision allows short-term opportunities to be evaluated objectively and thoroughly.
- *Look for partnerships* – Both public/public and public/private partnerships provide resources for land assembly, financing, and streamlining project approval, thus increasing the chance of success.
- *Consider the needs of developers* – As its name implies, TOD relies on development. Therefore, plans must be feasible considering the local markets.
- *Get the parking right* – Done well, TOD reduces the need for parking. Jurisdictions should take this into account when setting minimum parking requirements near transit stations. In many cases, eliminating parking minimums entirely is appropriate.
- *Insure that individual projects serve the vision* – Most station areas will consist of multiple developments built at different times. However, each individual project should be designed to serve the overall vision.
- *Don't overbuild retail* – The retail market in the United States is still very much auto-oriented. Take care that market for transit-oriented retail is sufficient to fill the amount of retail planned.
- *Mix uses amongst multiple stations* – Mixing uses across multiple stations (e.g. stadiums, shopping centers, high-density residential) increases the number of trips for which transit is a good option.
- *Encourage buses* – While TOD will be centered around high-capacity transit, good connecting local bus service should also be provided and marketed to residents/employees.
- *Provide a range of housing options* – TOD is appealing to all income levels, and housing should be provided at many different price points.
- *Engage corporate attention* – Encourage employers to locate near transit by marketing the employee benefits of transit-accessible locations.

Comments: For several of the factors listed above, short case studies are also provided. Case studies that may be applicable for stakeholder interviews and/or full case studies include: Arlington County, Virginia; El Cerrito, California; Denver, Colorado; and San Diego, California.

Lai, *Integration of Land Use and Transportation – Development Around Transit Stations*, 2008

Applicable Guidebook Sections:

- Description of access alternatives and access issues

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☒ Heavy Rail/Subway ☒ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☐ Auto ☐ Transit ☐ Bike ☒ Pedestrian

Summary: Lai examines the relationship between land use and transportation as a tool for cities to address increasing traffic congestion concerns. He introduces the concept of Transit Oriented Development and describes the elements needed for it to be effective, one of which is access. The TOD concept builds on several important planning principles, the most important of which is quality pedestrian connections between stations and the origins and destinations. Focusing on pedestrians enhances transit access and improves its market, in addition to creating an attractive urban place.

The key to providing quality access is to create a pedestrian-friendly environment. The road network in the TOD area must be designed to meet the needs for both pedestrians and vehicles. Different types and classifications of roads may need to be rearranged and integrated to work together, and modifications to existing regulations and practices may be needed.

Comments: This article focuses mainly on development of TODs, and is not particularly access-focused.

Tumlin, Siegman and Millard-Bell, *How to Make Transit-Oriented Development Work*, 2003

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Factors that affect access decisions
- Decision-making framework

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☒ Heavy Rail/Subway ☒ Light Rail

☒ Bus Rapid Transit ☒ Commuter Express Bus ☒ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☒ Bike ☒ Pedestrian

Summary: This document provides a brief overview of the key elements of successful TOD, and how these elements can be achieved. It describes 3 D's of density, diversity, and design in basic terms, and notes that while each of the three are needed for success, density is the most critical. The key features of good parking management are also described as 1) limiting parking, 2) pricing, and 3) minimizing parking's aesthetic impacts.

Comments: Overall, this document provides a good summary of standard practice and theory related to TOD. Several relevant research projects and example case studies are mentioned briefly throughout. However, no new ideas or original research is presented.

CASE STUDIES AND AGENCY GUIDELINES

Washington Metropolitan Area Transit Authority, *WMATA Joint Development Policies and Guidelines*, 2008

Applicable Guidebook Sections:

- Decision-making framework

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☒ Heavy Rail/Subway ☐ Light Rail

☒ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☐ Bike ☐ Pedestrian

Summary: WMATA's Joint Development Policies and Guidelines lay out the procedural requirements for engaging in joint development with the agency. As a policy, WMATA encourages joint transit-oriented development near its transit stations. Specifically, it encourages projects that:

- Integrate WMATA's transit facilities
- Reduce automobile dependency
- Increase pedestrian/bicycle originated transit trips
- Foster safe station areas
- Enhance surrounding area connections to transit stations
- Provide mixed-use including housing and the opportunity to obtain goods and services near transit stations
- Offer active public spaces
- Promote and enhance ridership
- Generate long-term revenues for WMATA
- Encourage revitalization and sound growth in the communities that WMATA serves

The Guidelines also identify WMATA's goals for its joint development program. Those that pertain to access include:

- Promote TOD by giving priority to joint development proposals that contain the following smart growth development principles: reduce automobile dependency; increase pedestrian/bicycle originated transit trips; foster safe station areas; enhance surrounding area connections to transit stations, including bus access; provide mixed-use development, including housing in compliance with local laws and requirements; and the opportunity to obtain goods and services near transit stations and offer active public spaces.
- Implement station access improvements that support pedestrian, bicycle, bus, ADA, and automobile access consistent with each station area's particular station access needs as determined by WMATA's station access planning program.

Comments: The majority of the document deals with policy for engaging in joint development and has little relevance to access planning. Still, the decision-making framework for working with local jurisdictions and developers may provide value.

Cottrell, *Transforming a Bus Station into a Transit-Oriented Development: Improving Pedestrian, Bicycle, and Transit Connections*, 2007

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Evaluation tools
- Case study

Line-Haul Mode(s) Considered: Commuter Express Bus

☐ Commuter Rail ☐ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☒ Commuter Express Bus ☐ Ferries

Access Modes Considered: Transit, Pedestrian, Bicycle

☐ Auto ☒ Transit ☒ Bike ☒ Pedestrian

Summary: This paper presents the results of a case study to improve access to the El Monte bus station, an express bus station serving the I-10 corridor in the Los Angeles metropolitan area. The station is served by over 1,100 buses daily and accommodates over 20,000 daily passengers. Pedestrian access to the station is severely limited by freeways and other barriers.

Despite the fact that nearly 13,000 people live within 1 km. of the station, less than 1,000 have a feasible walking route to the station. As a result, only 4% of passengers access the station by walking. The author shows that several relatively simple pedestrian improvements totaling approximately $5M could increase the numbers of people with walking routes to the station by over 8,000, thus presenting improved opportunities for walk access to the station.

The paper also examines the possibility to improve the current network of feeder buses to increase access to surrounding neighborhoods. The author identifies several improvements to increase the efficiency of the routes to reduce travel time, and also suggests reducing headways. The paper also suggests a possible route for an Automated People Mover to connect the station to adjacent employment centers and a Metrolink station located approximately 1 kilometer away, but notes that such an improvement would be very costly.

Finally, the author notes that improvements to the bicycle network have the highest potential to increase the non-auto access to the station, as over 27,000 people live within easy biking distance. However, it is noted that the number of people who would take advantage of improved bicycle connections is unknown.

Comments: At the time of writing, none of the proposed improvements were implemented, so no evaluation of the actual effects of the various strategies was possible.

Fehr & Peers, *Measuring the Transportation Effects of Smart Growth*, 2006

Applicable Guidebook Sections:

- Evaluation tools
- Case study

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☐ Heavy Rail/Subway ☒ Light Rail

☒ Bus Rapid Transit ☒ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☒ Bike ☒ Pedestrian

Summary: This website describes methods for evaluating Smart Growth policies and plans. Smart Growth strategies include:

- Transit enhancements and transit-oriented development (TOD)
- Community and regional policies and land use plans that reduce the need to travel and minimize impacts.
- Streets that provide context-sensitive, multi-modal mobility for traffic, transit, pedestrians, and bicyclists.

Station access and general design considerations include:

- Matching transit mode to development context
- Transit-supportive land use
- Urban design, and livable streets
- Multi-modal LOS considerations – factoring all modes into LOS standards

Tools to measure performance of transit and Smart Growth/TOD include:

- Direct ridership forecasting
- Quantification of user benefits
- Assessment of corridor and station suitability for particular transportation modes
- Micro-simulation of multi-modal centers and their impact on traffic/transit

The website focuses on design guidelines and development goals that support transit and create vibrant communities. Case studies are provided for Sacramento, BART, Denver RTD, Caltrain, and others.

Swenson and Dock, *Implementing a Suburban Network of Transit-Oriented Development Centers*, 2004

Type of analysis: Case study

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Decision-making framework
- Case study

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☐ Heavy Rail/Subway ☒ Light Rail

☒ Bus Rapid Transit ☒ Commuter Express Bus ☐ Ferries

Access Modes Considered: Auto, Transit, Bike, Pedestrian

☒ Auto ☒ Transit ☒ Bike ☒ Pedestrian

Summary: This paper describes a case study of four potential transit-oriented development sites located in the Twin Cities metropolitan area, with respect to the need to consider local context throughout the planning and implementation process. The four sites were chosen to represent varied land use and transportation network characteristics, and include both green-field and redevelopment opportunities. Each site is located along a potential high-capacity transitway, for which a particular mode had not been chosen.

The results of the analysis indicate several policy implications for planning transit-oriented development. First, planning, and especially building, TOD is difficult when the actual transit is not yet in place. However, given the long-term nature of transit capital projects, this will often be the case in metropolitan regions without a well-developed high-capacity transit network. In these situations, planning for phased development, in which early phases can be accommodated without the provision of transit but which do not preclude high-density, walkable TOD from occurring in the future is important.

In addition, the authors note the importance of considering the transportation network in a broad context that takes into account transit access in addition to the provision of line-haul transit. Moreover, appropriate transit access strategies depend on local context. In green-fields, auto access may be expected to dominate for many years and should be accommodated in transit planning. In denser settings, access will rely primarily on non-auto modes.

Finally, good planning for TOD is dependent on strengthening transportation connections between new and existing development. Small nodes of TOD are unlikely to thrive unless they are well-connected to adjacent neighborhoods. Thus, the connection to high-capacity transit is not the only factor in success.

The paper also describes the results of modeling using the region's travel demand model to forecast the effects of TOD in the four case study locations. The results of the modeling showed that TOD and improved connectivity would substantially reduce growth in vehicle miles traveled per capita.

Holle, *Transit-Oriented Development: the Chicago Perspective*, 2008

Applicable Guidebook Sections:

- Case study

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☐ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☐ Auto ☐ Transit ☐ Bike ☒ Pedestrian

Summary: This document provides several case studies of transit-oriented development around stations along Chicago's Metra Rail, including Station Square at Prairie Crossing and Elburn.

Main conclusions of the review are that elements of TOD, such as high density, economic revitalization, and walkability encourage transit use and access to stations.

Comments: Much of the document is not directly relevant to TCRP B-38. However, the document does describe several examples of TOD around commuter rail stations that may be valuable to investigate further through the stakeholder interviews or case studies.

INTERNATIONAL

Renne, *Smart Growth and Transit-Oriented Development at the State Level: Lessons from California, New Jersey, and Western Australia*, 2008

Applicable Guidebook Sections:

- Case study

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☒ Heavy Rail/Subway ☒ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered: Auto, Transit, Bike Pedestrian

☒ Auto ☒ Transit ☒ Bike ☒ Pedestrian

Summary: Renne describes the policies for promoting TOD established in New Jersey, California, and West Australia, states with TOD policies considered progressive in their respective countries. The paper finds that statewide policy has a significant effect on TOD in all three locations, not only directly but also through indirect influences on local and regional policy. According to the author, seven US states were proactively involved in promoting TOD as of 2006, with several other states involved to a lesser degree.

Both New Jersey and California have a range of policies and incentives in place to encourage TOD around rail stations. These include tax credits, statewide plans, and requirements for local jurisdictions to develop plans to support the states' land use goals.

In Western Australia the state has established a goal of accommodating 60% of new growth in existing urban areas, and encouraging TOD is a key piece of that strategy. To direct the state's TOD activities, the TOD Committee was formed in 2004, comprising representatives of key state, regional, and local agencies. The TOD Committee is charged with reviewing the TOD potential for every rail station in the state according to six criteria:

- Strategic significance of location
- Potential for maximizing ridership
- Infrastructure needs
- Potential for socioeconomic benefits
- Potential partners
- Development Opportunities

Through this process, the Committee has identified land for future TOD, and works with the Western Australia Planning Commission to preserve development opportunities in these areas.

Planning for TOD is also governed by the Development Control Policy, a far-reaching policy that seeks to reduce automobile dependence and increase public transit and non-motorized transportation. This policy directs local government planning, requiring, for instance, that local jurisdictions plan for higher densities and reduced car parking. Local governments must update their local plans every five years.

However, as in the United States, there is often a mis-match between stated goals and reality, and TOD remains very much a niche development product, while auto-oriented suburbs continue to dominate the new housing market.

Comments: Through its description of state policies, this paper shows the important role that state governments can play in encouraging TOD and improving transit access. States with incentives for TOD, and policies that encourage or require local jurisdictions to create station area plans, are likely to have different transit access goals and needs than states that do not.

Park-and-Ride / Kiss-and-Ride

Park-and-ride facilities provide a large portion of ridership for many high-capacity transit systems, and will likely continue to play a large role for the foreseeable future to maximize transit ridership and availability. The success of park & ride is determined by many factors, including parking availability and ease of other access modes.

Where parking demand exceeds capacity, research shows that parking pricing and TDM measures can encourage auto drivers to switch to other access modes, but can run the risk of reducing ridership if not priced appropriately. While advanced parking management has not been shown to increase ridership significantly in the short-term, it does benefit customer satisfaction, which may have long-term benefits.

Compared to park-and-ride, there is a smaller focus on kiss-and-ride service. However, the available research indicates that this may be a relatively untapped market for transit agencies with potentially high benefits at low costs.

RESEARCH

Turnbull, Pratt, Evans, and Levinson, *TCRP Report 95: Traveler Response to Transportation System Changes, Chapter 3 – Park & Ride / Pool*, 2004

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Factors that affect access decisions

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☒ Heavy Rail/Subway ☒ Light Rail

☒ Bus Rapid Transit ☒ Commuter Express Bus ☒ Ferries

Access Modes Considered:

☒ Auto ☒Transit ☒ Bike ☒ Pedestrian

Summary: This report is one of 19 chapters in TCRP Report 95. It provides an evaluation tool (i.e., data) for assessing the impacts of park-and-ride and park-and-pool facilities. Case studies are also included.

This report discusses the purposes of park-and-ride/pool facilities, classifies types of park-and-ride/pool facilities, describes the limitations of the data assembled through the research effort, and summarizes research findings related to traveler response to park-and-ride/pool facilities.

Transit mode–specific assessments are included in the report. These assessments address parking space utilization and turnover, driving distance to park-and-ride/pools, parking costs, characteristics of park-and-ride/pool users and their trips, characteristics of the transit services that serve park-and-rides, and other factors that contribute to use of park-and-ride/pools. Other assessments relevant to TCRP B-38 address the following:

- Park-and-ride/pool access distance and location
- Park-and-ride/pool environment (e.g., congestion, visibility, lot spacing, surrounding density, and ease of access)
- Attributes and amenities internal to the park-and-ride/pool
- Park-and-ride/pool usage and capacity
- "Mode change penalty" (i.e., the transit user must still maintain an automobile and the automobile is not available for other uses while it is at the park-and-ride/pool)
- Park-and-ride/pool facility size, design, and amenities
- Impacts of park-and-ride/pools on the environment

Comments: This report presupposes a station area that relies on automobile access. It does not focus on station access by other modes.

Fehr & Peers, *Optimizing Transit Ridership Through Balanced Investment in TOD and Parking*, 2006

Applicable Guidebook Sections:

- Factors that affect access decisions
- Evaluation tools
- Case Study

Line-Haul Mode(s) Considered:

☐ Commuter Rail ☒ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☐ Bike ☒ Pedestrian

Summary: This case study examines suburban Bay Area Rapid Transit (BART) station areas along the A-Line corridor between Oakland and San Jose. The initial corridor assessment evaluates trade-offs between parking supply and TOD, analyzing three scenarios:

1. 2030 base case that includes Smart Growth land use intensification around most stations
2. Enhanced TOD that further intensifies land use around each station
3. Enhanced TOD and access scenario that increases parking and bus service at several stations in conjunction with the Enhanced TOD land use intensification.

The authors employed direct ridership models to assess the effects of TOD on ridership and access mode share. The models forecast the individual effects of TOD, parking supply, and bus service on BART boardings and modes of access and egress. These were based on statistical analyses of existing BART ridership to correlate station-by-station ridership with station-area parking, bus service, TOD households and employment, and other factors.

To evaluate the ridership effects of replacing parking spaces with TOD, the model identified a "balance-point" which represents the parking replacement rate required to maintain the existing number of boardings when adding TOD at the station. On average, this rate was found to be 80 percent parking replacement.

Ultimately, the study determined that Direct Ridership Models can quantify the relationship between ridership and station area land use, parking, and levels of feeder transit service. They can also be used to predict ridership and levels of access and egress. Lastly, in the case of BART's A-Line, the models indicated that intensification of land use can increase ridership even without any expansion to station parking, but that parking increases are needed in order to keep pace with population growth beyond the immediate station vicinity.

Dueker, et. al., *TCRP Report 40: Strategies to Attract Auto Users to Public Transportation*, 1998

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Factors that affect access decisions

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☐ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☒ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☐ Bike ☐ Pedestrian

Summary: This research paper examines considerations (primarily in policy) for encouraging public transportation use among automobile drivers. The analysis is based primarily on parking policies, pricing and availability of parking, and other factors that influence mode choice. This document does not explicitly discuss transit station access, rather it focuses on how parking policies influence drivers and their potential to consider other modes.

- This report focuses largely on the relationship between parking availability and price in a downtown/destination area and users' willingness to use transit instead of driving
- Strategies for encouraging transit use include:
    1. Increasing the price of parking (through various tax mechanisms)
    2. Cashing out employer-paid parking

3. Expanding meters and accompanying residential permit programs
4. Parking impact fees
5. Changes in zoning ordinances to restrict parking supply (through various mechanisms)
6. Shared parking
7. Transportation demand management (satellite parking, shuttles, preferential parking for carpools, transit incentive programs)

TDM measures were ranked as "low to moderate" in effectiveness in persuading SOV drivers to use public transportation

Levinson, Adams and Hoey, *NCHRP Report 155: Bus Use of Highways Planning and Design Guidelines, Appendix B*, 1975

Applicable Guidebook Sections:

- Evaluation Tools

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☒ Heavy Rail/Subway ☒ Light Rail

☒ Bus Rapid Transit ☒ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☐ Bike ☐ Pedestrian

Summary: This report provides a comprehensive source of information on bus operating characteristics and provides design guidelines for bus facilities. Much of the information in the report has been updated and is included in *TCRP Report 100*. However, Appendix B, which details a conceptual model for evaluating the cost-effectiveness of park-and-ride versus feeder service provides a potentially useful model of a tool to evaluate park-and-ride service. The results indicate that feeder service is often more costly in low-density areas than parking, due to the long distances buses must travel to pick-up and drop-off passengers.

The model has a number of simplifying factors that limit its accuracy. In particular, the model does not allow users to assess the ridership impacts of one strategy versus another. However, the simplifications also make the model easy to apply to a wide range of circumstances, and can provide results quickly. Simple models such as the one developed here may assist in the decision-making process by providing an objective means to look at a specific problem.

American Association of State Highway and Transportation Officials, *Guide to Park-and-Ride Facilities*, 2004

Applicable Guidebook Sections:

- Access issues and agencies
- Guidelines for transit access
- Factors that affect access decisions

Line-Haul Mode(s) Considered:

☐ Commuter Rail ☐ Heavy Rail/Subway ☐ Light Rail

☒ Bus Rapid Transit ☒ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☐ Transit ☐ Bike ☐ Pedestrian

Summary: This guide gives a general knowledge of the park-and-ride planning and design process. Its chapters include Defining the Park-and-Ride System; Park-and-Ride Planning Process; Operations and Maintenance of Park-and-Ride Facilities; and Architecture, Landscape and Art – Integral Parts of the Park-and-Ride Facility.

Goodman and Lutin, *Transportation Terminals in Transportation Planning Handbook – Chapter 18*, 1999

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Factors that affect access decisions
- Design

Line-Haul Mode(s) Considered:

☐ Commuter Rail ☒ Heavy Rail/Subway ☒ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☐ Bike ☒ Pedestrian

Summary: This chapter on transportation terminals contains information on planning studies and procedures; transit access to rapid transit stations, park-and- ride, light rail and heavy rail station platform design.

Weant and Levinson, *Parking*, 1999

Applicable Guidebook Sections:

- Park-and-ride

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☒ Heavy Rail/Subway ☒ Light Rail

☒ Bus Rapid Transit ☒ Commuter Express Bus ☒ Ferries

Access Modes Considered:

☒ Auto ☐ Transit ☐ Bike ☐ Pedestrian

Summary: The report covers the various aspects of parking – policies and programs, zoning, administration, costs and financing, demands and characteristics, site selection and planning, lot and garage design, off-street parking operation, and curb parking.

Chapter 6, Parking Demands and Characteristics contains several tables that pertain to Park-and-Ride. One table (Table 6-10) gives parking provisions at selected rail rapid transit and commuter-rail stations; the boarding passengers per parking space range from about 2.2 (PATCO Lindenwold Line, New Jersey) up to 32 (Howard Street Station, Chicago). Another table (Table 6-12) shows that the boarding passengers per space at commuter rail stations ranges from 1.9 to 4.2.

Chapter 7, Site Selection and Planning contains planning and design guidelines for Park-and-Ride at rapid transit stations. It identifies the role and rationale for Park-and-Ride facilities – Park-and-Ride involves the transfer of parking space from the city center outward along express transit routes. The types include parking at commuter rail stations, rapid transit and LRT stations, and at express bus/BRT stations. Suggested planning criteria include:

- intercepting motorists before major points of congestion
- frequent transit service
- locations between the market area served and the major activity center, usually the CBD – generally at least 5 miles from the city center
- compatible with the surrounding environment
- accessible from major approach roads

The chapter gives guidelines for site size, and site design. It contains several examples of Park-and-Ride garages and lots.

Comments: Additional criteria have emerged since publication of this report. For instance, it is now recognized that Park-and-Ride facilities must be located in areas that are perceived to be safe by users.

CASE STUDIES

Rephlo, Haas, Feast, and Newton, *Evaluation of Transit Applications of Advanced Parking Management Systems Final Evaluation Report*, 2008

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Factors that affect access decisions
- Case study

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☐ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☐ Transit ☐ Bike ☐ Pedestrian

Summary: This document summarizes the findings of an evaluation of two parking management systems and their impacts on parking utilization, transit ridership, traffic circulation, and customer satisfaction. Station access is considered in the context of automobile drivers who park at commuter rail stations and how their experience (and likeliness to use transit more) changes after the implementation of parking management systems.

- The two parking management systems evaluated were in Chicago, IL and Montgomery County, MD
- Parking utilization at Tinley Park and Hickory Creek stations in Chicago did not increase notably. Neither station was at capacity prior to implementing the parking management system. Only the Tinley Park station showed a slight lengthening of the morning peak hour as additional customers boarded late morning trains)
- In Montgomery County, the Glenmont parking garage was already at capacity, thus an increase in utilization was not expected. Instead, the garage was found to fill up faster in the morning, as fewer people parked before 8am. This could be due to customers being aware of capacity at the garage and not feeling the need to arrive as early to get a space (or bypass the garage entirely because of concern that they would not get a parking space).
- The parking availability information (signs noting number of available spaces at garages) was not found to have encouraged additional transit use, but in Montgomery County some survey respondents noted that they were more aware of parking alternatives such as the Norbeck lot.
- Although they did not conclusively indicate an increase in transit usage (only a slight increase was reported in Chicago at the Mokena/Hickory Creek and Tinley Park/80th Avenue stations), the parking management programs did improve customer satisfaction.

Schank, *Encouraging Kiss-and-Ride at Commuter Rail Stations*, 2002

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Factors that affect access decisions
- Case study

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☐ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☐ Transit ☐ Bike ☐ Pedestrian

Summary: Schank describes the benefits of kiss-and-ride transit access, and performs a case study of 14 rail stations to determine factors affecting the amount of kiss-and-ride access at each. The stations are located in the New York metropolitan area along the Long Island Rail Railroad (LIRR) and Metro North Railroad (MNR).

Schank notes that there are several benefits to encouraging kiss-and-ride access to commuter rail stations, including the cost of providing additional parking and/or transit service and opportunities to replace parking with station-area development. Despite these advantages, kiss-and-ride access is seldom a focus of access planning and generally accounts for a relatively small portion of station boardings. Kiss-and-ride access mode share averaged 10-15% across the stations for which data were available.

The paper uses data provided by LIRR and MNR to identify stations with seemingly similar characteristics but differing amounts of park-and-ride. Six MNR and eight LIRR stations were selected for site visits. The case studies showed that short-term parking and kiss-and-ride facilities were positively associated with kiss-and-ride use, while enforced curbside parking regulations decreased kiss-and-ride by reducing available space for drop-offs.

The results of the case studies led to development of five strategies that would appear to increase kiss-and-ride use:

- Marketing
- Provision of short-term parking
- Separate access for kiss-and-ride passengers to improve efficiency
- Enforce parking restrictions
- Improve signing and wayfinding

These factors are discussed qualitatively based solely on the author's field observations, and no indication is given as to the potential effectiveness of these strategies.

Comments: The author's approach to the case studies is limited by a lack of data on many of the stations. For instance, all site visits were conducted during midday, which allowed for observation of peak parking demand but did not allow for observation of peak-hour operations.

As a result, all of the conclusions are of a qualitative nature; additional research into these stations would be required to draw definitive conclusions.

Levinson, *Planning Transit Facility Parking for the Boston Metropolitan Area*, 1976

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Evaluation tools
- Case study

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☒ Heavy Rail/Subway ☒ Light Rail

☐ Bus Rapid Transit ☒ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☐ Transit ☐ Bike ☐ Pedestrian

Summary: This paper analyzes basic policy issues, planning parameters, and demand estimates associated with developing a park-and-ride plan for the Boston metropolitan area. It shows how transit facility parking can complement downtown parking supply. It sets forth planning procedures for estimating the number and location of park-and-ride facilities.

The origins of downtown parkers and the likely growth in CBD parking demand was used as a base. Since downtown parking supply was stabilized, the future space deficiencies were assumed to represent the demand for outlying park-and-ride facilities. The demands were allocated to various geographic sectors based upon their relative future population. These methods have applicability in other large metropolitan areas.

Transit Feeder Service

Transit feeder service is an attractive option for many people that live outside of walking distance to access transit service, especially for those without vehicles available or for whom the cost of parking is prohibitive. Moreover, feeder has congestion and emissions benefits of park-and-ride access. However, feeder service must be time-competitive with the automobile to be successful, which can make providing service costly, especially in low-density areas.

Developing feeder services that are both time-competitive and cost-effective would provide major benefits to transit services. Potential strategies include flexible route systems to increase routing efficiency and ITS to provide customer information and scheduling. Finally, coordinated fare policies and schedules between line-haul and feeder services are critical to building ridership.

RESEARCH

Urbitran Associates, Inc., *TCRP Report 116: Guidebook for Evaluating, Selecting, and Implementing Suburban Transit Services*, 2006

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Factors that affect access decisions

Line-Haul Mode(s) Considered:

☐ Commuter Rail ☐ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☒ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☐ Bike ☐ Pedestrian

Summary: This is a guidebook to examine the status of suburban transit services and land use environments and their relationship. Case studies evaluate transit success in suburban environments and provide background for the report's techniques for service development.

The document analyzes the nature of suburban development and how transit is- and can be-applied to areas of dispersed development. Suburban transit service types discussed include:

1. Fixed route
2. Deviated fixed route
3. Demand-response
4. Subscription service (including vanpools)

Access issues primarily relate to sidewalk coverage of suburban areas and the resulting effect on transit use and availability/attractiveness. Evaluation tools included case studies of transit

operators, a review of land use patterns, evaluation of transit service types, and indicators of transit success in particular environments (e.g., analysis of land use versus transit service and operating performance).

Guidelines for service types are based on local decision-making and local policies. Innovations in transit service (such as real-time vehicle location information) are critical to advancing public transportation in difficult to serve suburban contexts

Case studies are provided for King County Metro (Seattle), TriMet (Portland, OR), South Metro Area Rapid Transit (Wilsonville, OR), Denver RTD, Metropolitan Council (Minneapolis), Suburban Mobility Authority for Regional Transportation (Detroit), Broward County (FL) Transit, and Capital District Transportation Authority (Albany, NY).

TranSystems, Planners Collaborative, and Tom Crikelair Associates, *TCRP Report 111: Elements Needed to Create High Ridership Transit Systems*, 2007

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Factors that affect access decisions
- Case study

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☒ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☒ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☐ Auto ☒ Transit ☐ Bike ☐ Pedestrian

Summary: This research document, including its own literature review, summarizes the factors that influence transit system ridership, and identifies successful approaches to achieving ridership growth. Circulator services are included as part of the overall service expansion approach to generating ridership (i.e., providing new access modes to feed existing/trunk transit routes). Specifically, the route evaluation measures in this report focus on: Urban circulator, Urban feeder/ distributor, and Suburban feeder/distributor systems.

The document analyzes transit service environments and their relationship to approaches used to maximize system ridership. Policy considerations- including a review of fare policies- are also discussed, particularly in the context of suburban transportation and suburb-suburb trip generation. Marketing and information programs are considered key components of transit property efforts to grow ridership.

Access issues primarily relate to mode choice parameters (availability, frequency, etc.) and external factors such as land use, density of development, and relative location of major employers to transit. Specific station access issues are not discussed in detail.

The following transit systems are evaluated in the report:

- Advance Transit (Wilder,VT)
- BAT Community Connector (Bangor, ME)
- Baldwin Rural Area Transportation System (Robertsdale, AL)
- Capital Area Transportation Authority (Lansing, MI)
- Greater Cleveland Regional Transit Authority (Cleveland, OH)
- Orange County Transportation Authority (Orange, CA)
- Ride On (Montgomery Co., MD)
- Transfort (Fort Collins, CO)
- Tri-County Metropolitan Transportation District (Portland, OR)
- Utah Transit Authority (Salt Lake City, UT)
- Ventura Intercity Service Transit Authority (Ventura, CA)
- Whatcom Transportation Authority (Bellingham,WA)

Comments: This document focuses on approaches to ridership growth, including operating service adjustments (frequency, routing, schedule coordination, etc.), partnerships and coordination (inter-agency, university/employer passes, etc.), fare policy initiatives, and marketing and information programs. Access issues are not specifically addressed.

Urbitran Associates, Inc., *TCRP Report 55: Guidelines for Enhancing Suburban Mobility Using Public Transportation*, 1999

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Factors that affect access decisions

Line-Haul Mode(s) Considered:

☐ Commuter Rail ☐ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☒ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☐ Bike ☐ Pedestrian

Summary: This document provides guidelines developed to improve bus service planning with services most applicable and effective to dispersed suburban development. The research document analyzes the nature of six types of suburban development:

1. Residential suburbs
2. Balanced, mixed-use suburbs
3. Suburban campuses
4. Edge cities

5. Suburban corridors
6. Exurban corporate enclaves

A classification scheme of suburban public transit services is provided to describe the range of applications through:

1. Actions to modify and improve the overall suburban transit framework
2. Actions that create supporting/complementary services

The document also provides a summary of policy considerations to better serve suburban markets, e.g.,

1. Develop services around focal points
2. Connect land-use mixes that consist of all-day trip generators
3. Link suburban services (local shuttles) to the broader regional line-haul network
4. Obtain private sector support
5. Establish realistic goals, objectives, and standards
6. Develop supportive policies, plans, and regulations

Evaluation tools include case studies of transit operators, a review of land use strategies, evaluation of transit markets, and identification of actions to improve the transit network. Guidelines for transit success are tied to land use approaches such as the development of transit-supportive design guidelines, transit-oriented development (TOD), and regional growth management. The document includes case studies of NJ TRANSIT, Norwalk (CT) Transit District, Long Island Bus, Suffolk County (NY) Transit, and Westchester County (NY) Bee Line.

Cervero, *Office Development, Rail Transit, and Commuting Choices*, 2006

Applicable Guidebook Sections:

- Description of access alternatives and access issues

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☒ Heavy Rail/Subway ☒ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☐ Auto ☒ Transit ☐ Bike ☐ Pedestrian

Summary: Suburban office development is generally not well connected to transit. Transit ridership increases when employers subsidize transit costs, parking is limited, and quality feeder bus service is present. Policy-makers can promote transit-commuting to offices near rail stops by flexing parking standards, introducing high-quality feeder buses, and initiating workplace incentives such as deeply discounted transit passes.

Cervero developed a best-fitting binomial logit model for predicting transit commute choice among surveyed office workers. Variables were identified based on theory (e.g. travel time) or if they were statistically significant and yielded intuitive and reasonable results. The model did not include variables related to density, mixed-use attributes, and street design features around the stations because there was limited variation among the surveyed sites. The significant variables identified were:

- Auto travel times
- Frequency of feeder bus service
- Parking
- Employer transit subsidies
- Auto ownership levels

As the frequency of feeder bus service to the closest rail stations to surveyed office site increased, so did the odds of workers rail-commuting. In a sensitivity test, Cervero found that over the range of feeder bus frequencies, the differential in transit-commuting probabilities 30 to 40 percent, depending on how generous employers are in promoting transit (i.e., minimal parking and help with transit costs) or in accommodating the automobile (i.e., ample parking and no help with transit costs).

Levinson, Hoey, Sanders, and Wynn, *Bus Use of Highways: State of the Art*, 1973

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Examples of bus-rail interchange

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☒ Heavy Rail/Subway ☒ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☐ Bike ☐ Pedestrian

Summary: Appendix D contains case studies of bus terminals that serve outlying commuter rail and rapid transit stations in several U.S. and Canadian cities. The cities and the stations described are:

Chicago:

- Dan Ryan rapid transit line – 95th Street Terminal (bus bridge over freeway and rapid transit line).

- Dan Ryan rapid transit line – 69th Street Station (bus bridge over freeway and rapid transit line).

- Jefferson Park Bus Terminal serving O'Hare rapid transit line and commuter rail line.

Cleveland:

- Bus terminals, Brook Park and West Park rapid transit stations.

Philadelphia:

- 69th Street rapid transit, light rail transit and bus terminal.

Toronto:

- Islington and Warden Stations on Bloor Street line.

Comments: Since the publication of NCHRP 143, many other examples of bus-rail coordination have emerged in both the U.S. and Canada.

Levinson, et al, *TCRP Report 90, Bus Rapid Transit, Volume 2, Implementation Guidelines*, 2003

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Factors that affect access decisions

Line-Haul Mode(s) Considered:

☐ Commuter Rail ☐ Heavy Rail/Subway ☐ Light Rail

☒ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☐ Bike ☒ Pedestrian

Summary: Chapter 5 gives guidelines for Bus Rapid Transit station planning and design. It covers station location and spacing, station design features, BRT platform characteristics, and intermodal stations. There are several illustrative examples of local bus/BRT interchanges. The location, size, and site planning for park-and-ride facilities are discussed.

The chapter suggests the following BRT station spacing.

Main Arrival Mode	Spacing (Miles)
Pedestrians	0.25 – 0.33
Bus	0.5 – 1.0
Automobile	2.0

Levinson, *NCHRP Synthesis 69 Bus Route and Schedule Guidelines*, 1980

Applicable Guidebook Sections:

- Examples of service coordination
- Description of access alternatives and access issues

Line-Haul Mode(s) Considered:

☐ Commuter Rail ☒ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☐ Bike ☐ Pedestrian

Summary: This synthesis report focuses on bus service planning. Chapter 4 – Routes and Services, contains information on bus service coordination, with rail rapid transit lines. It shows how bus lines in Chicago, Toronto, and Washington D.C. were restructured to focus on rapid transit stations.

Comments: The Rapid Transit Lines in Chicago and Toronto have been extended resulting in changes in the bus routes servicing the Jefferson Park (Chicago) and Eglinton (Toronto) stations.

Levinson, *Chapter 13: System and Service Planning in Public Transportation*, 1997

Applicable Guidebook Sections:

- Rapid transit planning
- Service coordination
- Station spacing

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☒ Heavy Rail/Subway ☒ Light Rail

☒ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☒ Bike ☒ Pedestrian

Summary: This chapter contains information on rail transit planning. It coves system configuration and design: radial character, market penetration, through service, minimum branches and switching, high speed, wide station spacing, ample station access and maximum operational efficiency. It also contains operations planning guidelines.

Comments: The chapter provides an overview of transportation and development, the transit planning process, transit planning and public policies, transit planning (including service-coordination) rail transit planning, and estimating capacities and fleet requirements.

Vuchic, *Urban Transit Operations, Planning, and Economics*, 2004

Applicable Guidebook Sections:

- Description of access alternatives
- Rail transit station

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☒ Heavy Rail/Subway ☒ Light Rail

☒ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☒ Bike ☒ Pedestrian

Summary: Chapter 4 describes transit lines and networks. Chapter 5 covers planning of rail transit station locations. It includes a theoretical analysis of how rail station spacing relates to the distribution of boardings along the line. There is a brief discussion of park-and-ride facilities along the line. Average station spacings for various rail transit lines are given.

Comments: The book contains useful information for developing and operating transit networks. It also covers transit agency economics and organization, and transit systems planning and mode selection. There are many good examples of rapid transit lines including park-and-ride and network configurations.

CASE STUDIES

Yim and Ceder, *Smart Feeder/Shuttle Bus Service: Consumer Research and Design*, 2006

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Factors that affect access decisions
- Case study

Line-Haul Mode(s) Considered:

☐ Commuter Rail ☒ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☐ Auto ☒ Transit ☐ Bike ☐ Pedestrian

Summary: The paper describes a proposed flexible-route shuttle service providing access to the Castro Valley BART station for residents within a 2-mile radius of the station. The objectives of the survey were to determine demand for a smart shuttle system and assess the qualities of such a system that would be needed to make it successful. The survey used the results of 400 telephone surveys conducted through a random-digit-dial sample.

The results of the survey showed that over 70% of current BART users in the study area use the automobile as their primary access mode, and only 5% took public transit. When asked about their interest in using a shuttle to access BART, approximately 37% of respondents were either very or somewhat interested (4 or 5 on a 1-5 scale). As expected, participants rated travel time, cost and reliability as the most important aspects determining the attractiveness of the shuttle.

Participants also indicated a tolerance for approximately 5 shuttle stops prior to reaching their destination and a maximum of 10 riders per shuttle. This information may provide some guidance to developers of flexible route services in terms of the required vehicle fleet size and type needed to run an attractive service.

Note that the authors intended this as the first phase of a project to field test an actual smart shuttle system. However, as of this review, no such service appears to have been implemented. Details on how the system would be run are limited within the article, and no cost or ridership estimates are provided.

Comments: Overall, the results indicate a potential market for flexible-route transit service providing feeder service to high-capacity transit. However, there are several flaws with the paper's methodology that would tend to overestimate people's propensity to use the proposed shuttle system. The survey relies entirely on the results of the stated-preference survey, and does not discount the results to account for the fact that people generally over-estimate their willingness to use transit in stated preference surveys. In addition, respondents who stated that BART was not an option to meet their travel needs were not included. The paper does not indicate what percentage of people responded that BART was not an option; the size of this population may reduce the actual market for the shuttle system considerably.

Pedestrian and Bicycle Access

Pedestrian access to transit station is often considered a given, in which those passengers located less than 0.5 miles from the station will walk, and others will not. However, the research shows that there are many factors other than distance that affect the decision on whether to walk, including urban design, pedestrian facilities, crime, and individual characteristics. By considering these factors, agencies have the potential to increase walking mode share to stations.

In addition, surveys of walk access trips show that the average walk access trip is nearly 0.5 miles, and that many pedestrians walk more than 0.5 miles to access transit. This indicates that the traditional focus on only the first half mile may underestimate the actual potential for walking trips.

With regard to bicycle access, the international literature review shows that it is possible for bicycles to comprise up to 40% of transit access trips. However, realizing such a high percentage is largely dependent on factors outside transit agency control, as system-wide quality of bicycle facilities, topography, weather, and bicycle culture all play large roles in people's willingness to bike. Even so, research indicates that provision of bicycle facilities at transit stations, in particular high-quality bike parking, does have a significant impact on bicycle access.

Finally, pedestrian and bicycle improvements are often made by local jurisdictions. This points to the need for coordination between transit agencies and local jurisdictions to improve bicycle and pedestrian conditions. For instance, in the case of Miami-Dade, the MPO completed the bike parking plan for transit.

RESEARCH

Schneider, *Synthesis 62 Integration of Bicycles and Transit: A Synthesis of Transit Practice*, 2005

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Factors that affect access decisions
- Evaluation tools
- Case study (Several short snippets and comparative tables included throughout report)

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☒ Heavy Rail/Subway ☒ Light Rail

☒ Bus Rapid Transit ☒ Commuter Express Bus ☒ Ferries

Access Modes Considered:

☐ Auto ☒ Transit ☒ Bike ☐ Pedestrian

Summary: This resource focuses on how bicycles can and should be integrated with transit. It addresses both bus stop and rail stations. It does not differentiate between types of rail station (e.g. CBD, urban, suburban). A substantial portion of the synthesis focuses on bike parking at stations, and transport of bicycles on-board transit vehicles.

The review determined that several factors are key to determining the effectiveness of utilizing bikes to supplement transit and serve as an access mode:

- Availability of bicycle facilities
- Parking security
- Restrictions/Rules
- Marketing/ Awareness/ Education/ Public Surpport
- Maintenance
- User Demographics
- Climate
- Design of transit system

Short case studies are included throughout the report to provide examples. Case studies of bicycles as access modes for line-haul transit include:

- **Regional Transit Denver (RTD) -** security issues with various parking types at transit stations
- **TriMet, Portland Max Light Rail and Streetcar- Portland Oregon -** Bicycles on Light Rail
- **Washington State Ferries – Seattle, Washington -** Bicycles on Ferry Transit
- **Central Ohio Transit Authority (COTA**) uses and automated system for counting bicyclists using bike-on-bus service

Key conclusions and findings of the report include:

- Bicycle services help to attract more transit riders by extending the catchment area of their transit system and provide greater mobility to customers at the beginning and end of their trips
- Several agencies believed that their bicycle services help decrease automobile traffic congestion, reduce air pollution and improve the public image of transit.
- Compared with the costs of buses, rail cars, and automobile parking facilities it is inexpensive for transit agencies to purchase bicycle equipment, such as bike racks on buses, bike hooks in rail cars, and bike racks and lockers at transit stations.
- Agencies have generally experienced few maintenance problems with their bicycle services. Problems reported included obtaining replacement parts for broken bus bike racks, abandoned bicycles on bus racks and bus bicycle racks, bus bicycle racks interfering with windshield wipers and the need to remove the bus bicycle rack when a bus is towed. (p.40)

Comments: The piece explains that although good information exists for counts and quantitative methods, the authors did not obtain information on the quality of their trips. They assume that

an increase in ridership (which most agencies experienced after the first year of implementation) as a positive trip experience for those riders. However the participants were never contacted.

The synthesis also suggests that further study be conducted on the economic impact on the bicyclist users – how much out-of-pocket costs are impacted when riding on bicycle rather than as a pedestrian, trip time increase, convenience v. inconvenience, etc.

Herman, Komanoff, Orcutt, and Perry, *Transportation Alternatives Bicycle Blueprint, Chapter 9: Bicycles and Transit*, 1993

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Case Study

Line-Haul Mode(s) Considered:

☐ Commuter Rail ☐ Heavy Rail/Subway ☒ Light Rail

☒ Bus Rapid Transit ☐ Commuter Express Bus ☒ Ferries

Access Modes Considered: transit, bike,

☐ Auto ☒ Transit ☒ Bike ☐ Pedestrian

Summary: This resource outlines reasons to improve transit access for pedestrians and bicyclists in New York City. Proposed improvements include increasing the amount and variety of bike parking located at train stations. Case studies of successful transit access programs in Europe and Asia support some of the Plan's recommendations. The report outlines the advantages and benefits of improving non-motorized access, and provides planning-level cost estimates for improvements.

Results of the study showed a desire on the part of cyclists and transit riders for better bicycle access to transit. Transportation Alternatives' 1992 City Cyclist survey found strong support for improving bicycle-transit links. Access to subways was deemed "very important" by 56% of respondents and "somewhat important" by 31%; only 8% considered it unimportant (the remaining 5% of respondents did not express an opinion).

A 1980 survey of New Jersey rail commuters found that 47% of respondents would consider cycling from home to train stations if facilities were improved. [12] In a 1992 survey by the Town of Oyster Bay (Nassau County), 418 of 1724 respondents (24%) said they would cycle rather than drive to the Long Island Rail Road station if it had theft-proof bike lockers.

<u>Findings from Europe</u>

- The share of Dutch rail passengers who cycle to stations ranges from 23% in the four largest cities, to 42% at inter-regional stations and 44% for local stations.
- Bicycle parking is available at every Dutch railway station, and far outranks car parking. In this country of 12.5 million people, Dutch National Railway alone

maintains almost 200,000 bicycle parking spaces, and private operators maintain thousands more.
- Stations typically provide one bicycle space for every 2-3 daily boardings: train stations with over 5,000 boardings per day average 2,000 guarded bicycle parking spaces (with check tags), vs. only 200-250 spaces for autos. Stations with two to five thousand daily boardings average 800 guarded bike spaces, as well as 400 unguarded spaces on roofs or in the open.

Findings from Japan

- In Japan, an estimated 3 million bicycles are parked daily at rail stations, five times the volume in 1975, and several times greater than the number of commuter cars.
- In Japan, increased cycling to train stations in the 1970s led to national and local laws requiring parking facilities near rail stops, beginning in 1973.
- By the early 1980s, over a dozen Japanese companies were specializing in manufacturing and installing bicycle storage facilities.

Comments: The document is 10 years old and may provide a base line to identify improvements that have occurred in the past decade, especially for the sections: "Rail-Station Bicycle Parking" and "Station Parking conditions in the New York Area".

FHWA, *National Bicycling and Walking Study: Case Study No. 9 -- Linking Bicycle/Pedestrian Facilities to Transit*, 1992

Applicable Guidebook Sections:

- Factors that affect access decisions
- Evaluation tools
- Decision-making framework
- Case study

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☒ Heavy Rail/Subway ☒ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☐ Auto ☐ Transit ☒ Bike ☒ Pedestrian

Summary: This report provides a comprehensive look at all factors affecting pedestrian and bicycle access to transit. It includes information on context factors, and provides recommendations intended to increase investments in pedestrian and bicycle infrastructure within the built environment. Typical access mode splits under different built environment contexts are also provided.

The report notes that organizational weaknesses (termed "fragmented institutional authority), such as poor inter-jurisdictional and inter-agency cooperation often inhibit attention to pedestrian and bicycle access to transit, resulting in degradation of the door-to-door experience of using public transportation.

Evaluation tools for incorporating pedestrians and bicycles into transit access planning include:

- How GIS is used to support pedestrian planning in Montgomery County, MD; including pedestrian and bicycle factors in travel demand modeling;
- PLOS and "Pedestrian Environment Factor" in Portland, OR
- Capital v. Operating cost comparisons by mode access type, including parking requirements.

Case studies in the report include:

- A Northern Virginia Rail Transit Access study of 4 rail stations on the Orange line (conducted by the Metropolitan Washington Council of Governments)
- Non-motorized access to Metrorail stations in Montgomery County
- Bicycling and Bicycle-transit linkage in Los Angeles
- BART's Commitment to Bicycle Parking Facilities
- Boulder, CO, as a pedestrian friendly city
- Florida's State Transportation Plan's Bicycle element (1980)
- Seattle's 1991 Non-motorized access study in the planning of 4 stations
- Charlotte (NC)
- Los Angeles
- Houston, TX
- San Diego, CA
- Santa Clara, CA
- Sacramento, CA

Findings and conclusions of the document are summarized as a set of recommendations:

- Establish a clearing house of information on pedestrian and bicycle access.
- Establish guidelines for non-motorized transit access development. Guidelines should include:
    - Selection of bike-and-ride transit locations
    - Siting of bicycle parking facilities
    - Equipment selection
    - Bicycle access route improvements
    - Bike-on-transit programs
- Future research and pilot projects, should include:

- Factors affecting bike-and-ride demand, such as local area crime rates, bicycle parking pricing policies, parking technologies, and route improvements
- Marking techniques for bike-and-ride promotions
- Other bicycle-related facilities around rail stations such as bicycle transportation service centers and bicycle rentals.
- Effects of comprehensive bicycle-transit integration action programs in metropolitan areas of various sizes
- Using GIS tools to support and enhance pedestrian and bicycle access to transit.

Comments*:* This very comprehensive study is a valuable description of the state of non-motorized transit access at a particular point in time, 1990 and 1991 at the time of the passage of the Clean Air Act and ISTEA. Issues addressed in the study are relevant today, though transit oriented development is not addressed thoroughly.

AGENCY PLANS AND GUIDELINES

Bay Area Rapid Transit, *Bicycle Access and Parking Plan*, 2002

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Factors that affect access decisions
- Decision-making framework

Line-Haul Mode(s) Considered:

☐ Commuter Rail ☒ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☐ Auto ☐ Transit ☒ Bike ☐ Pedestrian

Summary: The plan is a component of BART's Station Access Plans, and provides the agency with strategies to enhance the attractiveness of the bicycle as an access mode. Currently, BART provides many station amenities for cyclists, including bicycle racks, bicycle lockers, and a "bikestation". There are also programs such as shared-use bicycle lockers, stairchannels (a smooth channel along the edge of a stairway that is used to roll a bicycle up and down the stairs), and a BART Bicycle Advisory Task Force. The plan sets a goal to enhance cycling attractiveness and increase bicycle mode share. To achieve this, BART has identified the following objectives:

- Provide safe and convenient bicycle access between communities and the BART stations.
- Provide secure, convenient and ample bicycle parking at all BART stations. Incorporate innovative solutions to meet parking demand given space, budgetary and maintenance limitations.
- Promote the bicycle as a viable access mode to the BART system.

Provide comprehensive guidelines for future station projects and transit village developments on BART property.

The plan also covers systemwide bicycle access and parking needs. The needs assessment identified the following key areas of concern related to access: wayfinding, conflict mitigation, convenience, and coordination with local jurisdictions and agencies. Bicycle parking focus areas include: bicycle security, station security, weather protection, personal safety, convenience, and ample supply.

In developing its bicycle access recommendations, the plan focused on three components of station design.

1. *Local Access to Station (i.e. off-site)* – Bicycles should be able to take a direct, safe, and well-marked route to the BART station. The responsibility for these falls to the jurisdiction, but could include good quality pavement, bicycle-safe drainage grates, and upgraded railroad track crossings. Signage on nearby bikeways will direct riders to the stations.
2. *Access to Bicycle Parking and Fare Gates* – Primary bicycle access to the station should be provided at each vehicle entrance, and separate bicycle/pedestrian entrances should be provided at all intersections adjacent to the BART property. Once on station property, marked routes should be identified to lead bicyclists to and from bicycle and vehicle entrances to the station, bicycle parking areas, and fare gates.
3. *Access to Station Platforms* – Accessible gates (wide enough to allow bikes to pass through) should be provided at all stations. Elevators should be designed to accommodate several bicycles and stairchannels should be installed on at least one set of stairs leading from the fare gates to the platform(s).

Planning for bicycle parking requires consideration of many factors including parking types, station locations, and supply. Security and convenience are the most important factors for bicyclists when seeking parking. BART categorizes parking into two classes. Class 1 is a method of bicycle parking that protects the entire bicycle and its components from theft, vandalism, and inclement weather. Class 2 parking is most appropriate for leaving a bicycle for 2 hours or less and can be provided with properly designed and located bicycle racks.

BART's approach to bicycle parking location varies by type and station area, which is summarized in the table below.

Finally, the plan also addresses station expansion projects, particularly those that include a transit village component. Bicycle access to the station from the surrounding major roads and bikeway must be maintained and, although pedestrian accommodations are the emphasis, they should not preclude bicycle travel. Bicyclists also must be allowed to cross these villages or be provided with direct and safe routes without conflicts with the autos and buses.

Table 3-1: Summary of Appropriate Bicycle Parking by Station Area						
	Paid Area	Free Area	Drip Line of Station	Surface Auto Pkg	Auto Pkg Garage	Off-site
Class 1						
Standard Lockers	Maybe	Yes	Yes	Yes	Yes	Yes
Space-efficient Lockers	Yes	Yes	Yes	Yes	Yes	Yes
Bikestation	Maybe	Yes	Yes	Yes	Yes	Yes
Bike enclosure	Maybe	Yes	Yes	Yes	Yes	Yes
Bike Tree™	No	No	Maybe	Yes	No	Yes
Bike Garage	No	No	No	Yes	No	Yes
Equipment Lockers	Yes	Yes	Yes	No	Maybe	No
Class 2						
"Wave"/"U" Racks	Yes	Yes	Yes	No	No	No
Space-efficient Racks	Yes	Yes	Yes	No	No	No

Comments: This plan provides extensive discussion of alternatives for addressing bicycle access to transit issues. This discussion includes descriptions of bicycle parking facilities, and strategies for providing bicycle access to transit stations and train platforms. The recommendations also address bicycle access during construction and provide ideas for promoting bicycling as an access mode to BART.

The plan's treatment of bicycle parking is particularly thorough. In addition to the bicycle parking facility descriptions provided in the recommendations section, Appendix B includes diagrams and photographs of parking facility options as well as a table of facility costs and dimensions.

Massachusetts Bay Transit Authority (MBTA), *Bikes on the T*

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Decision-making framework

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☒ Heavy Rail/Subway ☒ Light Rail

☒ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☐ Auto ☐ Transit ☒ Bike ☐ Pedestrian

Summary: This webpage details rules and regulations governing bicycles on MBTA transit vehicles. It also provides information on bicycle parking at transit stations and general rules for entering transit stations with a bicycle.

Comments: The rules and regulations posted on this webpage are more complete than those provided by some other transit authorities and therefore may serve as a model for implementation. Also of interest may be details on the bicycle cage at Alewife station and the passcard system established to provide access to it. The document focuses on the rider perspective as opposed to access planning issues.

Hagelin, *Bicycle Parking Plan for Miami-Dade Transit*, 2002

Applicable Guidebook Sections:

- Factors that affect access decisions
- Evaluation Tools
- Case Study

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☒ Heavy Rail/Subway ☒ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☐ Auto ☐ Transit ☒ Bike ☐ Pedestrian

Summary: This report was prepared by the Center for Urban Transit Research (CUTR) of the University of South Florida to develop recommendations to improve the bicycle parking facilities in and around Metrorail stations, park-and-ride lots, and other transit hubs. The report offers recommendations for types, amounts, and locations of bicycle parking needed at Metrorail and Metrobus hubs, estimated costs and potential funding sources, guidance for inclusion of bike parking in planned transit hubs, and a management plan for the administration and promotion of bicycle parking facilities.

The report includes research of other jurisdictions that have successfully planned and implemented bicycle parking plans and/or integrated bicycles with transit using innovative methods. The research team referred to these as the 5 peer communities (Portland, San Francisco, Atlanta, Long Beach and New Jersey Transit).

The researchers also created and issued surveys to bicyclists for the purpose of identifying their perceptions of current conditions and improvement needs. This set of tasks involved the design

and distribution of a flyer announcing the survey, the development of the survey instrument, and implementation. All information was provided in English, Spanish and Haitian Creole. More extensive and in-depth interviews were conducted with bicyclists based on their willingness to participate. The data collected from the survey and interviews were analyzed to develop an understanding of the needs wants and experiences of bicyclists that currently use the bus and rail systems. The survey results led the researchers to the following conclusions:

- Commuting cyclists interviewed said that they expected to be given a reward or special treatment for "doing the right thing" by not adding to the pollution and congestion caused by drivers.
- Interviewees would prefer that bicycle parking structures be covered and that could be easily monitored by security. The report does not specify if the preference was for bike parking in automobile parking garages, bike stations or simply outdoor racks with a roof. They did not feel that the current bike lockers are secure as they are not monitored and are often broken into or vandalized. The existing bike lockers seemed to be susceptible to theft and vandalism and did not give the impression that the bikes inside were secure.
- Security guards should be responsible for monitoring bicycle racks and responding to bicycle patrons that report abandoned bicycles. Bicycles that are taken away can be donated to charity organizations that repair bicycles and give them a home.
- Bicyclists noticed that poor neighborhoods do not receive quality bike parking or in some cases parking at all. Two of the interviewees used stations that were self-reported as being in "poor neighborhoods". One stated that the lack of any type of bicycle rack at Brownsville Station was directly related to the area's "reputation as a poor and high crime neighborhood.

The report also includes detailed information on bike parking types, including racks, lockers, and bike stations.

Comments: This report is based on experience in other cities showing that safe and convenient parking near transit is possible. The report delves into specific bicycle parking products, evaluating their pros and cons. It also makes recommendations for parking policies that will support the parking improvements. The Plan also includes strategies for marketing and promoting the new bicycle parking facilities.

The location-specific research is a useful model for other transit agencies. Further, David Henderson of the Miami-Dade MPO added that some of the recommendations have been implemented and that the MPO has begun monthly counts of bikes parked at train stations to evaluate the effect of new bike racks and seasonal variation.

Los Angeles County MTA, *Bike-Transit Center Implementation Plan*, 2004

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Factors that affect access decisions
- Case study

Line-Haul Mode(s) Considered:

☐ Commuter Rail ☒ Heavy Rail/Subway ☒ Light Rail

☒ Bus Rapid Transit ☒ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☒ Auto ☒ Transit ☒ Bike ☒ Pedestrian

Summary: This resource is a comprehensive guide for policymakers interested in establishing bike-transit centers. It is divided into two parts: 1) a bike transit center toolkit and 2) bike transit center implementation plans for four communities in Los Angeles County.

The bike transit center toolkit provides analysis and recommendations on the following issues:

- Site and location analysis (including space requirements for different parking arrangements and additional services)
- Demand analysis
- Design standards and models (including floor plans and elevations lockers, secure rack enclosures, and full-service bike-transit facilities)
- Site planning
- Access control and membership management system
- Operating scenarios and strategies
- Marking guidelines
- Pricing (including a table showing sample bicycle locker charges in the US)
- Funding options

Factors affecting access issues are also referenced n the "Site and Location Analysis" chapter of the toolkit, which discusses requirements and recommendations for locating a bike-transit station. Factors recommended for consideration when deciding where to locate a bike-transit station include:

- Bicycle Access—Can safe bicycle access be accommodated at this location? Do any major barriers exist to riding a bicycle? Barriers could include highways, freeway ramps, underpasses, etc. How well does this location connect to existing or planned bicycle paths?
- Connectivity—How well does this location link destinations, employment, or housing to public transportation?

The toolkit includes a series of brief case studies with photos and basic facts (date opened, operator, services, capitol cost, operating subsidy, parking spaces, average daily parks, status) from existing bicycle stations. It also includes detailed implementation plans for four communities: Pasadena, Norwalk, Los Angeles (North Hollywood), and Santa Monica. The implementation plans. With the exception of Santa Monica, where a site for a bike-transit center is not identified, all of the implementation plans propose building bike-transit centers at rail stations.

Comments: This resource provides useful information to city officials, local planners, and transit agency staff interested in increasing the bicycle mode split for station access, and provides an exhaustive treatment of bike-transit stations.

Alta Planning & Design, Leslie Scott Co., and Bicycle Solutions, *Metro Bicycle Transportation Strategic Plan (vol. 1), Metro Bicycle Transportation Account Compliance Document (vol. 2)*, 2006

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Evaluation tools
- Case study

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☒ Heavy Rail/Subway ☐ Light Rail

☒ Bus Rapid Transit ☒ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☐ Auto ☐ Transit ☒ Bike ☐ Pedestrian

Summary: This is a two-volume resource aimed at improving mobility in the Los Angeles region by making it easier to bicycle rail and bus stations. The first volume is called the Metro Bicycle Transportation Strategic Plan and is designed to be used by city, county, and transit agency officials in "planning regionally significant bicycle facilities, setting priorities for improved mobility through the use of the bicycle with transit, and filling gaps in the inter-jurisdiction bikeway network." The plan includes:

- A listing of 167 "bike transit hubs";
- 12 prototype Bike-Transit Hub Access Plans in different geographical and demographic regions of LA County, including descriptions of bicycle access conditions and recommended improvements for each site;
- A description of audit procedures for evaluating obstacles for bicycle access with accompanying audit table (also available electronically from Metro); and

- A toolbox of bicycle facility design measures that address the purpose of each facility, where to use it, and guidelines (photos and diagrams also included).

The second volume is called the Bicycle Transportation Account Compliance Document. This document provides an inventory of existing and proposed bicycling facilities, and gives estimates of past and future ridership and expenditures.

The 12 prototype Bike-Transit Hub Access Plans also serve as case studies. Five of the access plans deal with rail stations with bus access, while the rest are focused on bus stations.

Comments: This resource is useful as a model for presenting bicycle facility design measures, bike-transit audit guidance, and case studies.

District of Columbia Department of Transportation, *District of Columbia Bicycle Master Plan*, 2005

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Evaluation tools

Line-Haul Mode(s) Considered:

☐ Commuter Rail ☒ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☐ Auto ☐ Transit ☒ Bike ☐ Pedestrian

Summary: The bulk of this plan is devoted to a series of core and supporting recommendations aimed at developing a world-class bicycle transportation system in the District of Columbia. Improving access to transit is a major goal of the plan, and it provides a basic description of the sort of improvements that ought to be made, including additional bicycle parking (especially covered bicycle parking), better lighting and signage, and improved bicycling facilities on routes leading to stations.

A detailed description of the Bike Level of Service (BLOS) methodology used to inventory DC streets is provided in Appendix C . The BLOS methodology evaluates the perceived safety and comfort of cyclists on roadways with respect to motor vehicle traffic. BLOS ratings take into account factors such as road geometry, traffic volume, traffic speed, and striping.

Comments: The plan's recommendations on access to transit are very general and no distinction is made between providing access to transit at Metro stations in the central CBD and providing access to transit at Metro stations in outlying suburban locations. However, the BLOS

methodology may be useful in determining which streets in the vicinity of high capacity transit stations need improvements.

District of Columbia Department of Transportation, *District of Columbia Pedestrian Master Plan (Draft)*, 2008

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Evaluation tools
- Decision-making framework

Line-Haul Mode(s) Considered:

☐ Commuter Rail ☒ Heavy Rail/Subway ☐ Light Rail

☒ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☐ Auto ☐ Transit ☐ Bike ☒ Pedestrian

Summary: This Plan has two primary goals: 1) reducing the number of pedestrians killed and injured in crashes with motor vehicles; and 2) increasing pedestrian activity by making walking a comfortable and accessible mode of travel throughout all parts of the District. Transit access is mentioned throughout the plan, and one of the plan performance measures is to increase the "Number of pedestrians walking to transit to commute." Recommendations addressing access include:

Installing high visibility crosswalks adjacent to Metro stations; and
Exclusive pedestrian phases for every cycle for signals located next to Metro stations.

The plan uses a modified version of Oregon's Pedestrian Potential and Deficiency Indices to select priority corridors for detailed field work. Pedestrian potential is calculated based on scores associated with the proximity of pedestrian attractors and generators (e.g. metro stations, stadiums) and population/employment density. Pedestrian deficiency is calculated based on scores developed for walking along the roadway (includes sidewalk gaps, sidewalk width, presence of a planting strip, presence of street trees, traffic volume, and posted speed limit) and crossing the roadway (includes traffic volume, number of travel lanes, speed limit, presence of raised median or median island). Pedestrian crashes are also considered as factors.
Comments: This plan is a good source for pedestrian facility design guidelines. It also details a pedestrian demand methodology that might be useful in prioritizing projects in the vicinity of transit stations.

Maryland Department of Transportation, *Twenty Year Bicycle & Pedestrian Access Master Plan*, 2002

Applicable Guidebook Sections:

- Decision-making Framework
- Evaluation tools

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☒ Heavy Rail/Subway ☐ Light Rail

☒ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☐ Auto ☐ Transit ☒ Bike ☒ Pedestrian

Summary: The plan presents goals and strategies for achieving the following vision:

Maryland will be a place where people have the safe and convenient option of walking and bicycling for transportation, recreation and health. Our transportation system will be designed to encourage walking and bicycling, and will provide a seamless, balanced and barrier-free network for all.

A key goal of the plan is to "integrate and expand the State's bicycle and pedestrian facilities…" Enhancing and expanding bicycle and pedestrian access to transit is presented as one strategy for achieving this goal. The plan is meant to shape not only decisions made by MDOT (although MDOT is the primary target) but also decisions made by local agencies.

The plan provides several evaluation tools and performance measures:

- "Percentage of appropriate transit vehicles that can accommodate bicycles" as a performance measure for evaluating the plan's success.
- The plan's technical appendix describes how the Bicycle Level of Comfort (BLOC) model was used to evaluate some 4,750 miles of state roadways to determine where improvements were needed. Such an approach might also be used by a transit agency to prioritize needed bicycle improvements by station area.

Comments: This plan is short on specifics and long on broad brush policy prescriptions, which can provide a framework for developing a plan specific pedestrian and bicycle access. The description of how BLOC was used to evaluate state roads is perhaps the most valuable aspect of the plan.

CASE STUDIES

Dantas, *Improving Pedestrian and Bicycle Access to Selected Transit Stations*, 2005

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Factors that affect access decisions
- Case study

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☒ Heavy Rail/Subway ☒ Light Rail

☒ Bus Rapid Transit ☐ Commuter Express Bus ☐ Ferries

Access Modes Considered: [auto, transit, bike, pedestrian]

☐ Auto ☐ Transit ☒ Bike ☒ Pedestrian

Summary: This study identifies low-cost measures to improve bicycle and pedestrian access at 6 MBTA transit stations. The transit stations considered provide bus service and commuter, subway, or light rail service. Each case study provides a description of access alternatives and access issues. Access issues considered include station amenities, bicycle parking, station visibility, and access issues along specified routes.

The study identifies two key factors affecting access decisions, "safety" and "quality of access trip." "Safety" is defined as "the potential for exposure to crime or for injury due to collisions with vehicles, fixed objects, and other hazards." "Quality of access trip" is defined as "traveler's subjective, personal comfort with the surrounding environment in both its practical and its aesthetic aspects."

Comments: The case studies in this report might be helpful in understanding how specific access improvements can be applied at particular locations. However, the recommended treatments are standard practice. The document does not address the larger context of research on access to transit.

INTERNATIONAL

Martens, *The bicycle as a feedering mode: experiences from three European countries*, 2004

Applicable Guidebook Sections:

- Description of access alternatives and access issues
- Factors that affect access decisions
- Decision-making framework

Line-Haul Mode(s) Considered:

☒ Commuter Rail ☒ Heavy Rail/Subway ☐ Light Rail

☐ Bus Rapid Transit ☒ Commuter Express Bus ☐ Ferries

Access Modes Considered:

☐ Auto ☐ Transit ☒ Bike ☐ Pedestrian

Summary: Martens' paper describes the use of bicycles as a feeder mode to transit in three Western European countries: Germany, the United Kingdom, and the Netherlands. The results indicate that, as expected, bicycle use for access trips is generally comparable to overall levels of bicycle ridership for each country. Likewise, policies and infrastructure to support bicycle access to transit generally follow overall investments in bicycle infrastructure by country. Thus, the Netherlands has the highest amount of investment and ridership, followed by Germany, and then the United Kingdom.

When considering line-haul modes individually, however, the results were quite different. Faster public transit modes (e.g. commuter rail) showed levels of bicycle access comparable to national average of bicycle mode split. Bicycle access to rail ranges from 2% in the UK to 30% in the Netherlands. Slower modes, however, (e.g. buses and trams) had similar bicycle access mode shares across all three countries (approximately 5%). This indicates that in countries with well-developed bicycle networks, bicycles compete directly with local public transit services, but supplement longer distance rail services.

A comparison of trip purposes for bike-and-ride travelers by country is also provided, showing that trip purposes are similar across the three countries. In all countries, work and education trips account for over 70% of the total bicycle access trips to transit. Travel distances of bicycle access trips are also similar, with 70-80% of travelers traveling no more than 4km by bicycle. Car availability appeared to have little impact on the decision to bike to a rail station, but was highly correlated with the decision to use a bicycle to access bus service. Finally, bicycles were not used heavily as an egress mode in any of the surveyed countries, indicating that few passengers prefer to take their bicycles on-board transit vehicles, or purchase a second bicycle for the egress trip.

Comments: The results of the study indicate that while overall bike-and-ride mode splits vary considerably between countries, the characteristics of the users themselves share several similarities, as described above. Many of these, such as the maximum length of bicycle access trips and the preference to use bikes to access higher speed transit are likely to apply to the United States as well.

References

1. Alta Planning & Design, Leslie Scott Co., and Bicycle Solutions, *Metro Bicycle Transportation Strategic Plan, Volume 1, Metro Bicycle Transportation Account Compliance Document, Volume 2*, Los Angeles County Metropolitan Transportation Authority (June 2006).

2. American Association of State Highway and Transportation Officials, *Guide to Park-and-Ride*, Washington, D.C., 2004.

3. Ayvalik, Cemal K., and C. Jotin Khisty, "Heuristic Analysis of Impacts of Commuter Rail Station Consolidation on Pedestrian Access," *Transportation Research Record,* Number 1793, pp. 47-54 (2002).

4. Banister, David, John Pucher, and Martin Lee-Gosselin, "Making Sustainable Transport Politically and Publicly Acceptable," in Rietveld, P. and Stough, R., eds., *Institutions and Sustainable Transport: Regulatory Reform in Advanced Economies.* Cheltenham, England: Edward Elgar Publishing, pp. 17-50 (2007).

5. BART Customer Access Department, *BART Bicycle Access and Parking Plan, Volume 1*, Bay Area Rapid Transit District Customer Access Department, BART (August 2002).

6. Bay Area and Rapid Transit, *Bicycle Access and Parking Plan*, Wilbur Smith Associates (August 2002).

7. Bay Area Rapid Transit Planning Department, *16th and Mission BART Station Access Plan* (2002).

8. Bay Area Rapid Transit, *BART Station Access Guidelines*, San Francisco (2003).

9. Burkhardt, McGavock, Nelson and Mitchell, *TCRP Report 82: Improving Transit Options for Older People, Volume 2, Final Report* (2002)

10. Cervero, R., C. Ferrell, and S. Murphy, *Transit-oriented development and joint development in the United States: A literature review,* TCRP Research Results Digest 52. Washington, DC: National Research Council. 2002.

11. Cervero, Robert, "Walk-and-Ride: Factors Influencing Pedestrian Access to Transit," *Journal of Public Transportation,* Vol. 3, No. 4 (2001).

12. Cervero, Robert, *Office Development, Rail Transit, and Commuting Choices*, Journal of Public Transportation, Vol. 9, No. 5, (2006).

13. Cottrell, Wayne D., "Transforming a Bus Station into a Transit-Oriented Development: Improving Pedestrian, Bicycle, and Transit Connections," *Transportation Research Record,* Number 2006, pp. 114-121 (2007).

14. Daley, Louis, *Wareham Intermodal Transportation Center Site Analysis*, Southeastern Regional Planning & Economic Development District (November 2005).

15. Dantas, Lourenco, *Improving Pedestrian and Bicycle Access to Selected Transit Stations*, Massachusetts Highway Department (September 2005).

16. Debrezion, Ghebreegziabiher, Pels, Eric A.J.H. and Rietveld , Piet, *Modelling the Joint Access Mode and Railway Station Choice*, Tinbergen Institute Discussion Paper No. 07-012/3 (January 2007).

17. Denton County Transportation Authority (specific author unknown), *Station, Operations, & Bicycle Facilities Planning Guidelines*, Denton County Transportation Authority (April 2006).

18. Denver RTD Fastracks, *Transit Access Guidelines* (June 2008).

19. *District of Columbia Bicycle Master Plan*, District of Columbia Department of Transportation (April 2005).

20. *District of Columbia Pedestrian Master Plan*, District Department of Transportation (May 2008).

21. Dowling, Richard, David Reinke, Aimee Flannery, Paul Ryus, Mark Vandehey, Theo Petritsch, Bruce Landis, Nagui Rouphail, and James Bonneson, *NCHRP Report 616: Multimodal Level of Service Analysis for Urban Streets*, Transportation Research Board (May 2008).

22. Dueker, Kenneth J., *Report 40: Strategies to Attract Auto Users to Public Transportation*, Transportation Research Board/Transit Cooperative Research Program, Transportation Research Board (1998).

23. Dunphy, Robert, Deborah Myerson, and Michael Pawlukiewicz, *Ten Principles for Successful Development Around Transit*. Washington, D.C.: ULI - Urban Land Institute (2003).

24. Evans, John E. IV, Richard H. Pratt, Andrew Stryker, and J. Richard Kuzmyak, "Transit Oriented Development," *TCRP Report 95: Traveler Response to Transportation System Changes, Chapter 17*, Transportation Research Board (2007).

25. Federal Highway Administration, *National Bicycle and Walking Study: Case Study No. 9 – Linking Bicycle/Pedestrian Facilities to Transit*, Federal Highway Administration (October 1992).

26. Federal Transit Administration, *Station Area Planning: How to Make Great Transit-Oriented Places* (2008).

27. Fehr & Peers, "Measuring the Transportation Effects of Smart Growth," www.smartgrowthplanning.org (2006).

28. Fehr & Peers, *Optimizing Transit Ridership Through Balanced Investment in TOD and Parking*, San Francisco (2006).

29. Fort Worth Transportation Authority (specific author unknown), *Southwest-to-Northeast Rail Corridor – Station Planning Process & Guidelines*, Fort Worth Transportation Authority (September 2007).

30. Givoni, Moshe and Piet Rietveld, "The access journey to the railway station and its role in passengers' satisfaction with rail travel," *Transport Policy*, Volume 14, pp. 357-365 (2007).

31. Glotz-Richter, Michael, *Moving the City: A Guided Tour of the Transport Integration Strategy in Bremen, Germany* (2003).

32. Goodman, Leon and Lutin, Jerome E., *Chapter 18 Transportation Terminals in Transportation Planning Handbook*, Second Edition, John D. Edwards, Editor, Institute of Transportation Engineers, Washington, D.C., 1999.

33. Hagelin, Christopher, *Bicycle Parking Plan for Miami-Dade Transit*, Miami-Dade MPO (2002).

34. Herman, Michele, Charles Komanoff, Jon Orcutt, David Perry, "Transportation Alternatives Bicycle Blueprint, Chapter 9: Bicycle and Transit," Transportation Alternatives (1993).

35. Hoel, Lester A. and Roszner, Ervin S., *Transit Station Planning and Design: State of the Art*, Transportation Research Institute, Carnegie Mellon University, Pittsburgh, PA 1976.

36. Holle, Gena, *Transit-Oriented Development: the Chicago Perspective*, Community Transportation, Winter (2008).

37. Institute of Urban and Regional Development (University of California at Berkeley), Parsons Brinckerhoff Quade & Douglas, Inc., Bay Area Economics, and Urban Land Institute, *TCRP Report 102: Transit-Oriented Development in the United States – Experiences, Challenges, and Prospects*, Transportation Research Board (2004).

38. Jon E. Burkhardt, Adam T. McGavock, Charles A. Nelson, and Christopher G. B. Mitchell. *TCRP Report 82: Improving Transit Options for Older People, Volume 2, Final Report*, Transportation Research Board, Washington, DC (2002).

39. Kim, Sungyop, Gudmundur F. Ulfarsson, and J. Todd Hennessy, "Analysis of light rail rider travel behavior: Impacts of individual, built environment, and crime characteristics on transit access," *Transportation Research Part A*, Volume 51, pp. 511-522 (2007).

40. Kittelson & Associates, Inc., Herbert S. Levinson Transportation Consultants, and DMJM+Harris, TCRP Report 118, *Bus Rapid Transit Practitioner's Guide*, Transportation Research Board, Washington, DC (2007).

41. Kittelson & Associates, Inc., KFH Group, Inc., Parsons Brinckerhoff Quade & Douglass, Inc., and Katherine Hunter-Zaworski, *TCRP Report 100: Transit Capacity & Quality of Service Manual, 2nd Edition*, Transportation Research Board (2003).

42. Kittelson & Associates, Inc., Urbitran, Inc., LKC Consulting Services, Inc., MORPACE International, Inc., Queensland University of Technology, and Yuko Nakanishi. *TCRP Report 88: A Guidebook for Developing a Transit Performance-Measurement System,* Transportation Research Board, Washington, DC (2003).

43. Kuby, Michael, Anthony Barranda, and Christopher Upchurch, "Factors influencing light-rail station boardings in the United States," *Transportation Research Part A,* Volume 38, pp. 223-247 (2004).

44. Lai, Peter, *Integration of Land Use and Transportation – Development Around Transit Stations,* Princeton, New Jersey (2008).

45. Levinson, H.S. *Chapter 13 System and Service Planning* in Gray G.E. and Hoel, L.A. Public Transportation Second Edition, Prentice Hall, Englewood Cliffs, New Jersey, 1997.

46. Levinson, Herbert S, *NCHRP Synthesis 69 Bus Route and Schedule Guidelines,* Transportation Research Board, National Research Council, Washington, D.C. May, 1980.

47. Levinson, Herbert S. "Planning Transit Facility Parking for the Boston Metropolitan Area" in Transportation Research Record 601. Freeways, Automatic Vehicle Identification and Effects of Geometrics, Transportation Research Board, Washington D.C. May, 1976.

48. Levinson, Herbert S., Crosby L. Adams, and William F. Hoey, *NCHRP Report 69: Bus Use of Highways Planning and Design Guidelines, Appendix B*, Transportation Research Board (1975).

49. Levinson, Herbert S., Hoey, William F., Sanders, David B., and Wynn, F. *Houston NCHRP Report 143 Bus Use of Highways State of the Art,* Highway Research Board, National Research Council, Washington D.C. , 1973.

50. Los Angeles County MTA, CalTrans, and Bike Station, *Bike-Transit Center Implementation Plan*, Los Angeles County Metropolitan Transit Authority (October 2004).

51. Loutzenheiser, D.R., "Pedestrian access to transit: model of walk trips and their design and urban form determinants around Bay Area Rapid Transit stations," *Transportation Research Record,* Number 1604, pp. 40-49 (1997).

52. Martens, Karel, "The bicycle as a feedering mode: experiences from three European countries," *Transportation Research Part D,* Volume 9, pp. 281-294 (2004).

53. Maryland Department of Transportation, Twenty Year Bicycle & Pedestrian Access Master Plan, Maryland Department of Transportation (October 2002).

54. MBTA, *Bikes on the T*, http://www.mbta.com/riding_the_t/bikes/

55. NJ TRANSIT, *Station, Operations, & Bicycle Facilities Planning Guidelines*, NJ TRANSIT (March 2008).

56. Park, Sungjin and Junhee Kang, "Factors that Influence Walking and Biking to the Station: Modeling Commuter Rail Users' Access Mode Choice," *Transportation Research Board 2008 Annual Meeting,* Washington, D.C. (January 2008).

57. Pucher, John, "Urban transport in Germany: providing feasible alternatives to the car," *Transport Reviews*, Vol 18. No. 4, pp. 285-310 (October 1998).

58. Renne, John, "Smart Growth and Transit-Oriented Development at the State Level: Lessons from California, New Jersey, and Western Australia," *Journal of Public Transportation,* Vol. 11, No. 3 (2008).

59. Rephlo, J., R. Haas, L. Feast, and D. Newton, *Evaluation of Transit Applications of Advanced Parking Management Systems Final Evaluation Report,* U.S. Department of Transportation, Federal Transit Administration, 2008.

60. Schank, Joshua L., "Encouraging Kiss-and-Ride at Commuter Rail Stations," *Transportation Research Record,* Number 1793, pp. 7-14 (2002).

61. Schneider, Robert, Toole Design Group, "TCRP Synthesis 62 Integration of Bicycle and Transit: A Synthesis of Transit Practice," Transportation Research Board (2005).

62. Schwartz, WL, CD Porter, GC Payne, JH Suhrbier, PC Moe, WL Wilkinson III, *Guidebook on Methods to Estimate Non-motorized Travel*, Federal Highway Administration (July 1999).

63. Sonoma-Marin Area Rail Transit (SMART), *White Paper No. 12 – SMART Station Planning*, Sonoma-Marin Area Rail Transit (May 2008).

64. Swenson, Carol J. and Frederick C. Dock, "Implementing a Suburban Network of Transit-Oriented Development Centers," *Transportation Research Record,* Number 1885, pp. 71-78 (2004).

65. Transit Station Access Committee *56th Technical Council Information Report,* Institute of Transportation Engineers, December, 1980.

66. Transportation Research Record Volume 2042 – Intermodal Facilities and Capacity; Light Rail, Commuter Rail, and Rail Transit; and Major Activity Center Circulation Systems, Transportation Research Board, 2008.

67. TranSystems, Planners Collaborative, Inc. and Tom Crikelair Associates, *TCRP Report 111: Elements Needed to Create High Ridership Transit Systems,* Transportation Research Board, National Academy Press, (2007).

68. TriMet, *Design Criteria Manual, Chapter6 – Stations*, TriMet (June 2005).

69. Tsamboulas, Dmitrios, John Golias and Marios Vlahoyannis, "Model development for metro station access mode choice," *Transportation,* Volume 19, pp. 231-244 (1992).

70. Tumlin, Jeffrey, Patrick Siegman, and Adam Millard-Bell, *How to Make Transit-Oriented Development Work*, American Planning Association (May 2003).

71. Turnbull, Katherine F., Richard H. Pratt, John E. Evans IV, and Herbert S. Levinson, "Park-and-Ride/Pool," *TCRP Report 95: Traveler Response to Transportation System Changes, Chapter 3*, Transportation Research Board (2004).

72. Urbitran Associates, Inc., Report 116: Guidebook for Evaluating, Selecting, and Implementing Suburban Transit Services, Transportation Research Board/Transit Cooperative Research Program, Transportation Research Board (2006).

73. Urbitran Associates, Inc., *Report 55: Guidelines for Enhancing Suburban Mobility Using Public Transportation*, Transportation Research Board/Transit Cooperative Research Program, National Academy Press (1999).

74. Vuchic, Vukan, R., *Urban Transit Operations, Planning, and Economics,* John Wiley and Sons, Hoboken, New Jersey, 2004.

75. Washington Metropolitan Area Transit Authority, *Metro Station Access & Capacity Study* (2008).

76. Washington Metropolitan Area Transit Authority, *WMATA Joint Development Policies and Guidelines* (2008).

77. Weant, Robert A., and Levinson, Herbert S., *Parking*, ENO Foundation for Transportation, Westport, CT 1998.

78. Willson, Richard and Val Menotti, "Commuter Parking Versus Transit-Oriented Development: Evaluation Methodology," *Transportation Research Record,* Number 2021, pp. 118-125 (2007).

79. Yim, Y.B and Avishai Ceder, "Smart Feeder/Shuttle Bus Service: Consumer Research and Design," *Journal of Public Transportation,* Vol. 9, No. 1 (2006).