Best Practices in Transit Service Planning

Project #BD549-38

FINAL REPORT

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16. Abstract

The provision of cost efficient and effective bus transit service is the basic premise upon which transit service is developed and the goal that all public transportations agencies strive to achieve. To attain this goal, public transit agencies must design their services around clear and defined principles, as well as a process to monitor the results achieved and to respond accordingly. This requires service design standards, an effective performance measurement system, and a systematic and continuous service evaluation methodology.

This research identifies existing best practices in transit service planning and develops a generic model approach that could be adapted and used by public transit agencies for fixed route bus transit service planning, specifically to include Service Design Standards, Service Performance Measurements, and a standard Service Evaluation Methodology. This research effort provides a summary of best practices and provides a "template" process tool that can be adapted and customized for use by all sizes public of transit agencies.

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Executive Summary

The provision of cost efficient and effective bus transit service is the basic premise upon which transit service is developed and the goal that all public transportations agencies strive to achieve. To attain this goal, public transit agencies must design their services around clear and defined principles, as well as a process to monitor the results achieved and to respond accordingly. This requires service design standards, an effective performance measurement system, and a systematic and continuous service evaluation methodology.

The focus of this research project is limited to fixed route bus service. The goal of the effort was to provide a blueprint around which a public transit agency could approach transit service planning. This includes providing a structured approach to allow transit service planners to react in an objective and grounded manner to requests for new service, modifications to services, expansion of services, and in reductions of service during times of budget restrictions.

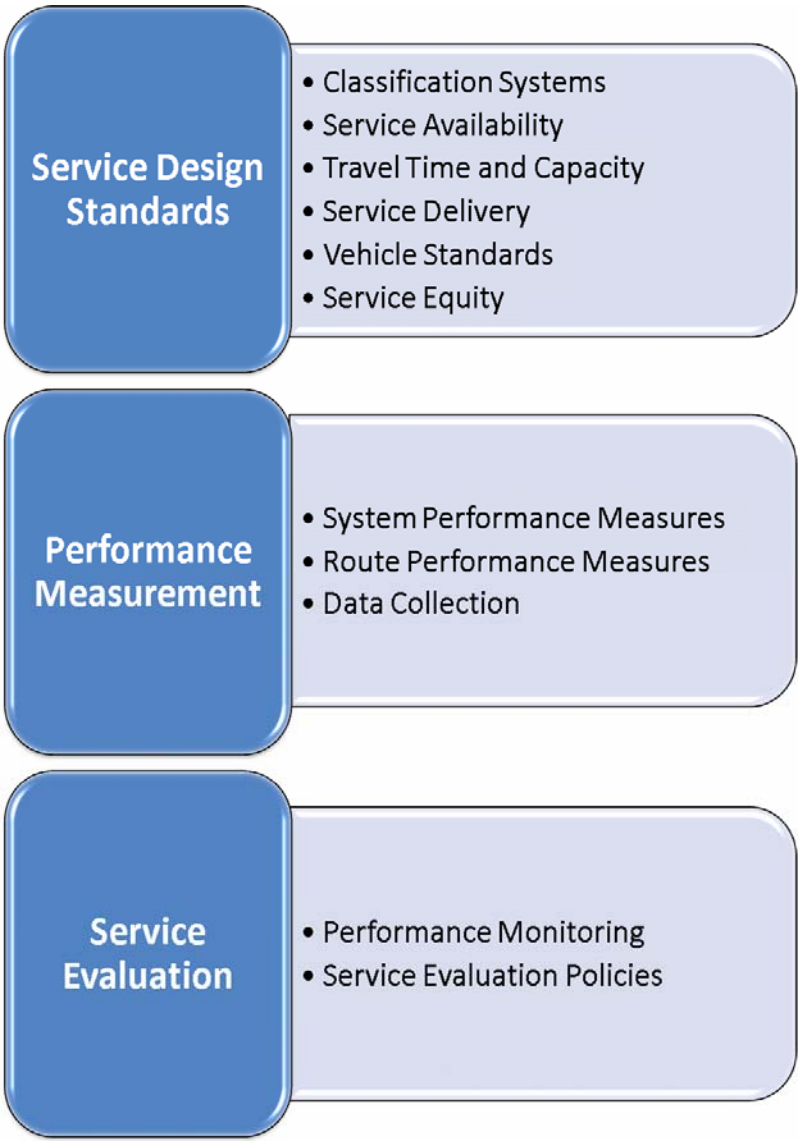
The guiding principles of the research were to define operating standards and philosophies, provide a framework for transit service planning, and formalize a decision process to make transit service changes.

The objective of this research was to identify existing best practices and develop a generic model approach that could be adapted and used by all public transit agencies for fixed route bus transit service planning, specifically to include Service Design Standards, Service Performance Measurements, and a Standard Service Evaluation Methodology. The focus of the research was on short term transit service planning, including its relationship to efficient route planning and scheduling. The results of this research effort provide a summary of best practices and a "template" process tool that can be adapted and customized for use by all sizes of public transit agencies. The end product permits public transit agencies to have transit service planning reference tools and processes that could be locally customized to account for local operating environments and policies.

This research consisted of several major project tasks: a literature review, a summary of the bus transit service planning processes and procedures currently utilized by Florida transit and national transit properties, a compilation of current and best practices, and the development of a model approach or template for an agency to develop and structure its transit service planning approach.

An early task in this research effort was to conduct a literature review of previous studies, reports, and research related to transit service planning and is organized around three general transit service planning topics:

- Part I – Service Design Standards
- Part II – Performance Measurement and Standards
- Part III – Service Evaluation Methodology



During the research effort, Florida and national public transit agencies were consulted to identify current industry practices in transit service planning. An electronic survey was created and sent to all transit systems in the United States that are APTA members, plus the Florida transit agencies that are not APTA members, for a total of 352 transit agencies. Responses were received from 63 agencies, for an overall response rate of approximately 18 percent. The results of the survey have been compiled and are analyzed in Chapter Three.

Building upon the previous tasks, best practice case studies were developed for five transit agencies based on thoroughness, completeness, and the applicability to one of the three major service planning themes.

The final phase of the research applies the findings and lessons learned to develop a model approach for a transit system to use as a guide for service planning in the three main areas – service standards, performance measures, and service evaluation methodology. This chapter explains the purpose of a systematic approach to service planning and defines the key components that should be part of any service planning program.

Transit service planning professionals utilize a terminology that, in some cases, is unique to the transit operations planning field. To assist the reader in understanding this terminology, an appendix is included in this report that provides definitions and explanations for 110 terms used in the transit service planning profession.

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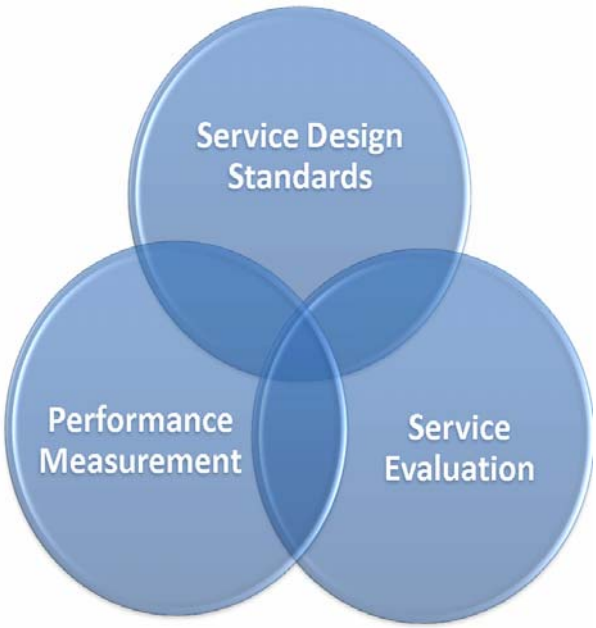
Project Overview

Project Objective

The provision of cost efficient and effective bus transit service is the basic premise upon which transit service is developed and the goal that all public transportations agencies strive to achieve. To attain this goal, public transit agencies must design their services around clear and defined principles, as well as a process to monitor the results achieved and to respond accordingly. This requires service design standards, an effective performance measurement system, and a systematic and continuous service evaluation methodology.

The focus of this research project is limited to fixed route bus service. The goal of the effort was to provide a blueprint around which a public transit agency could approach transit service planning. This includes providing a structured approach to allow transit service planners to react in an objective and grounded manner to requests for new service, modifications to services, expansion of service, and reductions in service during times of budget restrictions.

The guiding principles of the research were to define operating standards and philosophies, provide a framework for transit service planning, and formulize a decision process to make transit service changes.



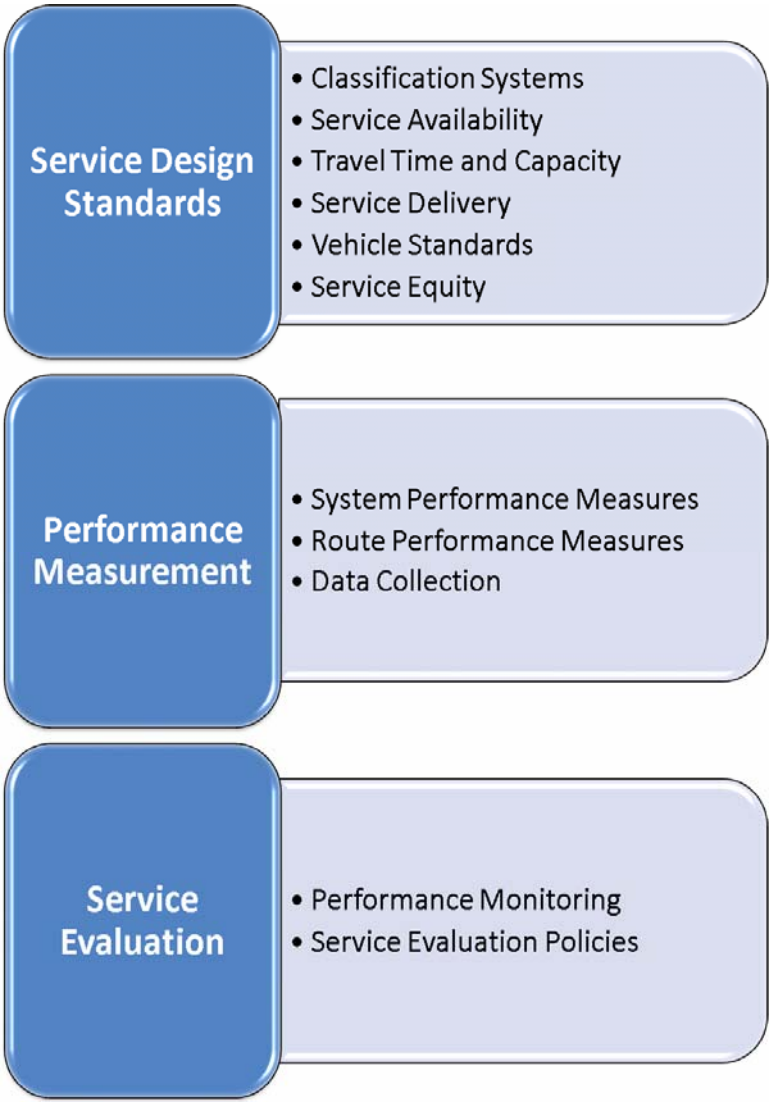
The objective of this research was to identify existing best practices and develop a generic model approach that could be adapted and used by all public transit agencies for fixed route bus transit service planning, specifically to include Service Design Standards, Service Performance Measurements, and a Standard Service Evaluation Methodology. The focus of the research was on short term transit service planning, including its relationship to efficient route planning and scheduling. The results of this research effort provide a summary of best practices and a "template" process tool that can be adapted and customized for use by all size public transit agencies. The end product permits public transit agencies to have a transit service planning reference process that would allow local development and customization.

Report Organization

This report summarizes the findings of the major project tasks: a literature review, a summary of the bus transit service planning processes and procedures currently utilized by Florida transit agencies and select national transit properties, a compilation of current and best practices, and the development of a model approach or template for an agency to develop and structure its transit service planning approach. This material is organized as follows.

Chapter Two – Transit Service Planning Chapter Two provides a summary of the review of previous studies and research related to transit service planning and is organized around three general transit service planning topics:

- Part I – Service Design Standards
- Part II – Performance Measurement and Standards
- Part III – Service Evaluation Methodology



Chapter Three – Consultation with Transit Agencies: During the research, Florida and national transit agencies were consulted to examine current industry practices in transit service planning, with focus on three primary areas: service design standards, performance measurement, and service evaluation methodologies. Surveys were sent to all transit systems in the United States that are APTA members, plus the Florida transit agencies that are not APTA members, for a total of 352 transit agencies. Responses were received from 63 agencies, for an overall response rate of approximately 18 percent. The results of the survey have been compiled and are analyzed in Chapter Three.

Chapter Four – Case Studies: Best Practices in Service Planning: Chapter Four builds on the previous chapters by selecting a few transit service planning approaches to be examined in greater depth. The planning approaches that were chosen for this chapter were based on thoroughness, completeness, and the applicability to one of the three major service planning topics.

Chapter Five – Transit Service Planning – Model Approach: Building on the previous four chapters, Chapter Five takes the lessons learned and applies them to a modeling approach for a transit system to use as a guide for service planning in the three main areas – service standards, performance measures, and service evaluation methodology. This chapter explains the purpose of a systematic approach to service planning and defines the key components that should be part of any service planning program.

Appendix – Glossary of Transit Service Planning Terminology: Transit service planning professionals use terminology that, in some cases, is unique to the transit operations planning field. To assist the reader in understanding this terminology, an appendix is included that provides definitions and explanations of 110 terms used in the transit service planning profession.

Chapter Two

Transit Service Planning Overview

Introduction

The provision of cost efficient and effective bus transit service is the basic premise upon which transit service is developed and the goal that all public transit agencies strive to achieve. To attain this goal, public transit agencies must design their services around clear and defined principles, as well as a process to monitor the results achieved and to respond accordingly.

This chapter provides a summary of the review of previous studies and research related to transit service planning and is organized around three general transit service planning topics:

- Part I – Service Design Standards
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Part I - Service Design Standards

Service design standards refer to specific goals, objectives, or policies that an agency sets for itself in various areas of service design. The standards exist in many varieties, spanning all facets of a transit system. Based on some common threads that emerged after scanning the industry literature, the following six areas are explored in this literature review.

- **Part I-A: Classification Systems or Service Types** are often used in conjunction with the other five areas to provide variable standards based on the type or classification of service.
- **Part I-B: Service Availability** standards address service area characteristics, service coverage, route layout and design, and stop location and spacing.
- **Part I-C: Travel Time and Capacity** standards address the frequency, directness, span of service, and passenger loading.
- **Part I-D: Service Delivery** standards address on-time performance, passenger shelters, transit amenities, customer service, and safety issues.
- **Part I-E: Vehicle Standards** address the assignment of vehicles, utilization and efficiency, and reliability and condition.
- **Part I-F: Service Equity** addresses FTA Title VI requirements for standards.

I-A Classification Systems

As reported in TCRP Synthesis 10 – "Bus Route Evaluation Standards" (1995), some systems have guidelines (i.e., standards) that differ for each type of service (i.e., classification). For example, express buses or buses that operate over limited access roadways might not be scheduled to carry standees, whereas local buses would carry standees. In the survey conducted for this report, almost 58 percent of transit agency respondents indicated they had different guidelines for different types of service.

There are many ways that transit agencies divide their services into types, but the various methods can generally be divided into four basic groups:

- **function of the number of stops or service frequency**
- **function of the population served**
- **function of route design**
- **function of time of day**

The first group classification is a **function of the number of stops or service frequency**. When making this distinction, transit agencies will generally define a group of routes that make up the majority of their system and label them as ***local service*** or regular, base, core, or similar adjective that defines them as their average route. A local service is a route that operates primarily on arterial streets, with a minimum of eight stops per mile and an average operating speed of 15 mph or less, according to the "Service Policy for Surface Public Transportation - Massachusetts Bay Transportation Authority" (1975). Another definition cited in the "York Region Transit Service Guidelines" (2006) is service that ensures a basic level of access throughout the service area, connecting major trip origins and destinations.

Another distinct type of service as a function of service levels is ***limited stop service***. This type of service varies from regular route service by having fewer stops and operating at higher speeds. Limited stop services tend to operate in outlying areas with direct service along a freeway or arterial to increase operating speed and help to reduce loads at high activity/transfer stops.

Rapid service or ***BRT* (*Bus Rapid Transit*)** is a form of limited stop service that combines a much higher service frequency. BRT service is also known for the use of technologies such as transit signal priority, off-board payment, and queue-jump lanes to increase the speed of the service.

Express service takes limited stops to the extreme by serving two distinct points with no or few stops in between. Express service is often used to carry a significant number of passengers from a major origination point (possibly a park-n-ride lot) to a major destination point (typically, a high density working environment). Express services are typically designed to use the fastest route between the two points and may be routed on expressways to satisfy this desire.

Flexible service or ***route deviation*** allows for deviations from the general route path to provide direct transportation access to passengers who live in the vicinity of the basic route path. On request, and perhaps for an additional charge, the vehicle will deviate a few blocks from the route to pick up or deliver a passenger. This service is most often provided with smaller vehicles and provides service in a designated area (typically lower density).

Extremely low density service also referred to as ***life-line or peripheral service*** provides some level of minimal service in areas with low population density or low transit use. This type of service typically operates on secondary streets. Extremely low density services usually operate with one-hour headways or higher and may not operate a full day or every day. They are operated primarily to provide accessibility to transit-dependent populations that have no other alternative. While productivity is low, this type of service is often less expensive to run as compared to demand response services. It also can serve as a vital connection to more frequent service.

The second grouping is to classify based on the **function of the population served.** One such population group is commuters. ***Commuter/work-based service*** provides direct service to an employment center from outlying areas with special provisions for employees. The service may or may not be open to the general public. It may be a completely new route or a modified existing route that accounts for shift changes and other work characteristics. In some instances, the transit agency will enter into a financial partnership with organizations to provide these services.

Another function of service by type of population is ***community-based service***. This type of service serves a specific community or area, typically for transit dependent populations such as seniors or persons with disabilities who are able to use conventional fixed route transit. It may also focus on providing better access to the facilities oriented to this customer market.

Student-based transportation encompasses yet another population type. Service tailored specifically to students of schools and universities should provide a high-level of service with limited stops and more direct routing. While school districts are typically required to provide transportation for students that reside more than two miles from the school, students that live within that boundary may be in need of some type of public transportation. As for universities, campuses that have limited parking availability can benefit greatly by providing direct transit service from off-campus housing. On-campus shuttles enable students to get around more quickly than by foot.

Special event service is used to transport a targeted population – those attending a specific, infrequent event. Special event service is usually scheduled where the projected attendance of an event exceeds parking availability or when the event will create significant traffic congestion. Some systems set thresholds based on the attendance of the events. Special event service is also a tool to protect surrounding neighborhoods from the impact of the event (overflow parking) or the normal transit service (overloading).

Regional service provides transportation that is regional in nature, connecting one major urban area with another major urban area. Regional routes are typically long with few stops and act as a limited stop or express type of service.

The third way to classify routes in a system is a **function of route design**. According to TCRP Synthesis 10, 48 percent of systems set standards based on this classification. The most common classifications for route design are radial or trunk, cross-town, circulator, feeder/shuttles, and regional routes.

Radial routes (or trunk routes) are the backbone of a transit system and operate mainly along arterial streets. Radial routes typically serve the Central Business District (CBD) or urban core and are considered the nucleus of the transit network. These routes are characterized by frequent stops, short passenger trips, and relatively slow average bus speeds.

Cross-town routes, on the other hand, are non-radial in nature and do not serve the CBD directly. Cross-town routes are used to link major activity centers with direct routing or serve high density corridors outside the CBD. They generally intersect radial lines, and schedules should be coordinated to provide optimal transfer connections.

Circulator routes provide service that is confined to a specific location, typically downtown or residential areas. Circulators connect to major activity centers and allow passengers to transfer to other routes to gain access to the rest of the network. They typically operate in a loop fashion, sometimes with only one-way directional service.

Feeders or shuttle **service** provide service in higher density or higher demand areas that feed to other routes in the system, an activity center, or another mode of transportation (air, rail, etc.). Routing is generally short and as direct as possible to maximize customer convenience. Special event service can be classified as feeder service.

Regional service provides transportation that is regional in nature, connecting one major urban area with another major urban area. Regional routes are typically long with few stops and act as a limited stop or express type of service.

The fourth way to categorize types of service is by a **function of time of day**. Transit systems often provide different levels of service during peak periods, non-peak periods, nighttime, Saturdays, and Sundays, and therefore will likely have different standards based on these time periods.

Peak period service, which often lasts for about three hours in the morning and three hours in the afternoon/evening, provides a greater level of service for commuters. ***Non-peak service*** refers to the hours of service between the peak periods. ***Night service*** (or owl service) is a type of service that extends beyond normal transit operating hours. Many agencies establish specific standards before they consider operating night service. Some examples of the threshold standards include a history of high

ridership, specific evidence of non-traditional work hours in the area, and equitable service distribution. Night service may also have a modified route structure.

Throughout the remainder of this literature review, a list of performance measures that are commonly used with each corresponding planning standard are displayed in the accompanying box.

Measures for _____

Type 1
- ***Measure 1***
- ***Measure 2***

Type 2
- ***Measure 3***
- ***Measure 4***

Type 3
- ***Measure 5***

I-B Service Availability

Service availability measures the passenger's ability to access and use transit. Standards for service availability address **service area characteristics**, **service coverage**, **route layout and design**, and **stop location and spacing**.

Service area characteristics involve specific characteristics that could increase the propensity (i.e., likelihood of use) of the population to use transit and are often displayed in a graphical format. Standards in this area are important for a transit system to establish so that they provide the level of service warranted and not over- or under-serve any one area.

Demographic data from the U.S. Census is the most commonly used data source for service area characteristics. ***Population density*** represents the number of people residing per square mile and is the most common measure used by agencies to evaluate potential usage of the system. It is the best representation of ridership potential at the point of origin. Nearly 74 percent of transit agencies use this measure as a criterion for route design, as cited in TCRP Synthesis 10 (1995).

Some example standards using the service area characteristic of ***population density*** include:

- The density of population and employment in an existing or proposed service area should be closely examined to reveal the level of transit service that may be supported (Palm Tran Service Guidelines 1999).

- Transit service should be designed to provide a higher degree of accessibility to areas of high density (7 to 17.9 dwelling units per residential acre) and medium density (2.2 to 6.9 dwelling units per residential acre) than to areas of low density development or areas protected from development (Milwaukee County TDP 2005-2009).

- The density of development along a route is a primary factor in providing service to outlying suburban or rural areas. Generally, a minimum of three dwelling units or three employees per acre are required to warrant bus service (Line Service Design Standards - VIA Metropolitan Transit 2000).

- The adopted Miami-Dade County Comprehensive Plan states that mass transit service should operate at a minimum of one-hour service within Traffic Analysis Districts (TADs) that have a combined population and employment density of 10,000 persons/square mile (Miami-Dade Transit Service Guidelines 1998).

Another major factor that determines transit propensity is ***employment density***. Employment density represents the number of jobs per square mile. Typically, work trips account for well over one-half of a transit system's ridership. Almost 66 percent of respondents to the survey in TCRP Synthesis 10 use this measure in route design.

Example standards using ***employment density*** include:

- VIA Metropolitan Transit in San Antonio, Texas, will consider peak period service to all work sites where 500 or more persons work for a single employer and where 1,000 or more persons work for several employers. Workers must have similar shift times to be considered for service.

- The transit supportive land area should be maximized. To be considered transit supportive, an area should have a density of at least four dwelling units per net

Measures for Service Area Characteristics

Population Density
- ***Persons per square mile***
- ***Dwelling units per acre***
- ***Minimum no. of households***

Employment Density
- ***Employees per square mile***
- ***Employees per acre***
- ***Employees per employer (threshold)***

Age
- ***Population age 18 and younger***
- ***Population age 60 and older***

Income
- ***Number of households with incomes less than $10,000***
- ***Per capita income***

Vehicle Availability
- ***Zero car households***
- ***One-car households***

residential acre or at least four jobs per gross acre (Milwaukee County TDP 2005-2009).

Aside from population density and employment density, some agencies use other measures to determine transit propensity. Examples include:

- Characteristics such as ***household income*** can be used to determine accessibility and can be applied to the entire system to determine how to add appropriate service to poorly served areas (TRR 1841, 2003).

- Other service area characteristics that can be used to identify transit ridership potential include the ***number of low-income households*** (usually those households with annual incomes less than $10,000), ***the number of elderly and youth*** (those persons over the age of 60 and under the age of 18), and the ***number of zero-vehicle households*** (Palm Tran Service Guidelines 1999).

- ***Minimum levels of development*** should exist before serious consideration is given to providing service. Statistically, residential areas with a minimum of 200 households and major destinations such as employment centers, shopping centers, and major leisure time areas are candidates for transit service. Justification for service is based on market research that examines the socioeconomic composition to assess the need and propensity to use transit (Line Service Design Standards - VIA Metropolitan Transit 2000).

- ***Persons with no auto ownership*** will show a far greater propensity to ride transit than those who can choose to drive (Triangle Transit Authority – Regional Bus Service Standards 2003).

Service coverage measures the extent to which the defined service area is being served. Service coverage is commonly measured by the percentage of the population that resides within ¼ mile walking distance of a bus stop. It is generally accepted that a user will walk a ¼ mile to reach a bus stop to use the service. This measure is also known as service area population in the National Transit Database (NTD).

Examples of standards involving this measure include:

- With a density of more than 4,000 persons/square mile, 90 percent of the population should be within ¼ mile ***walking distance***. With 2,000 to 4,000 persons/square mile, 60 percent of the population should meet this condition (FTA Introduction to Transit Workshop 1997).

- An area is considered “well-served” if a stop is no more than ¼ mile from passenger’s origin point and a minimum of 30 minutes of service frequency is provided. An area is considered “served” if a stop is no more than ½ mile from passenger’s origin point and a minimum of 60

minutes of service frequency is provided (Suburban Transit Division Service Standards and Process – SEPTA 2004 revised).

- The population should be considered as "served" when it is within ¼ mile walking distance from a bus stop for local service and ½ mile from express or rapid service (Milwaukee County TDP 2005-2009).

- A location is considered "served" if transit service operates within ¼ mile of the location (Line Service Design Standards - VIA Metropolitan Transit 2000).

- CTA's service coverage policy is to provide a maximum walking distance of ½ mile to transit service during peak periods. A walking distance of ¼ mile is required for high density areas and one mile walking distance for night (owl) service (Chicago Transit Authority Service Standards 2001).

- AC Transit, which serves the Alameda-Contra Costa Transit District in California, has the following walking distance to bus route standards:

    - 20,000 persons/square mile or higher – ¼ mile walking distance
    - 10,000-20,000 persons/square mile – ¼ to ½ mile
    - 5,000-10,000 persons/square mile – ½ mile to ¾ mile
    - 0-5,000 extremely low density – 1 mile or greater

- Maximum walking distance is 500 meters (1640 feet) in the daytime (Monday-Saturday), and 1000 meters (3280 feet) for all other periods. The objective of this standard is to provide service to approximately 90 percent of the urban area (York Region Transit – Transit Service Guidelines 2006).

- For local routes, service should be available within ¼ mile for 85 percent of residents. For feeder routes, service should be available within ½ mile for 90 percent of residents. For flexible routes/demand response, 100 percent should be within ¾ mile (as designated by ADA) (City of Folsom Short Range Transit Plan Update 2005).

Measures for Service Coverage

Walking Distance
- ***Percentage of population within ¼ mile or ½ mile walking distance***

Per Capita Measures
- ***Vehicle miles per capita***
- ***Revenue hours per capita***

Park and Ride Measures
- ***Number of spaces available***
- ***Autos served per day***

- Residential areas with seven or more units/ acre should be within ¼ mile of a local route and ½ mile from a feeder route. In areas with fewer than seven units/acre, service should be provided within 1 mile (City of Folsom Short Range Transit Plan Update 2005).

Service coverage can also be defined by calculating a common transit measure such as vehicle miles operated or revenue hours supplied to the service area population. These are known as **"per capita"** measures. While agencies do not typically set standards based on per capita measures, they are commonly used in peer analysis and transit development planning.

Another facet of service coverage involves the ***availability of park-and-ride facilities***. Park-and-rides extend the use of the transit system beyond the everyday user to include automobile users. Standards are often used to govern the use and specifications of the park-and-ride facilities. Some examples are:

- Park-and-ride facilities should be provided at appropriate stops on rapid and express services to serve transit users from medium and low density residential areas. Sufficient off-street auto parking should be provided at park-and-ride facilities to accommodate the total parking demand (Milwaukee County TDP 2005-2009).

- Park-and-ride facilities may be provided at any suitable location which can be shown to attract 200 autos per day within three years for express service and 150 autos per day for limited stop service (Line Service Design Standards - VIA Metropolitan Transit 2000).

The **route layout and design** of the system can also impact service accessibility. Aside from placing services where they will have the most transit market potential, several additional characteristics are often taken into consideration. One consideration is the ***spacing between routes,*** which is measured by the average distance between parallel routes. Parallel routes operating closer than ½ mile to each other have the potential to split the demand for service. In areas characterized by low demand, this can result in several routes competing for the same passengers. Therefore, a trade-off must be made between an acceptable walking distance and the frequency of service provided in these areas. Factors affecting route spacing include geographical conditions, population concentrations, and trip generators and attractors. In general, service should be spaced at one mile along major arterials, and ½ mile in the urban core (Palm Tran Service Guidelines 1999).

Other examples of route spacing standards include:

- The key routes are primarily spaced one mile apart, with high density service spaced ½ mile apart and owl service spaced two miles apart (Chicago Transit Authority Service Standards 2001).

- In urban core areas, routes should be spaced ¼ mile apart. In less densely populated areas, routes should be spaced no further than one mile apart (Service Evaluation & Performance Measurement Program - Madison Metro 2000).

Roadway conditions and safety concerns associated with those conditions are other factors that influence the layout and design of routes. Some systems utilize standards that specify the type of streets where transit can safely operate. Examples include:

- Service will be operated only over asphalt or concrete paved streets with at least 10-foot lanes. Service will not be operated over streets that continually exhibit danger-producing situations such as steep grades, poor condition, or habitually illegal parking reduces the roadway width to less than 10 feet (Service Policy for Surface Public Transportation - Massachusetts Bay Transportation Authority 1975).

- Public transit service should not be operated over streets that exhibit conditions that may be hazardous for transit operations, including steep grades, narrow traffic lanes, uncontrolled intersections, poor pavement conditions, or habitual problems with illegal parking (Milwaukee County TDP 2005-2009).

- New bus routes should not be operated along streets that do not meet the following criteria – 10-foot lane width, no speed bumps, overhead clearance – 12-foot, asphalt or concrete surface, turning radius of at least 35 foot (Service Standards - RTD [Denver, CO] 2002).

Another standard of route design is the ***avoidance of duplication of service*** along the same streets or corridors. Examples of standards used to avoid duplication of services include:

- Operations of competitive, overlapping or redundant regular route services will be avoided except on thoroughfares where additional service is warranted or at a major transfer point or activity center (Service Policy for Surface Public Transportation - Massachusetts Bay Transportation Authority 1975).

- Request for changes to SEPTA's route structure will not be considered if they duplicate existing service (Suburban Transit Division Service Standards and Process – SEPTA 2004 revised).

Measures for Route Design/Layout

- ***Distance between parallel routes (miles)***
- ***Roadway specifications***

- Public transit routes should be arranged to minimize duplication of service (Milwaukee County TDP 2005-2009).

Stop location and spacing is yet another facet of service delivery**.** The location of bus stops has always been one of the more controversial issues within the transit industry as there is no consensus on which are better - ***far-side or near-side stops***. Various considerations swing the argument to the preference for far-side or near-side. It is generally accepted that ***mid-block stops*** are sub-optimal, but they may be the best choice under certain circumstances (TCRP Synthesis 10 1995).

Some considerations that agencies have made concerning ***stop location standards*** include the following:

- The Florida Department of Transportation Transit Office have sponsored two research efforts that focus on the design and planning for transit facilities that address a wide range of subjects related to transit service planning, including suggested standards and guidelines for bus stop locations and spacing. (refer to References section of this report for the reports – Accessing Transit Version 2 and Florida Department of Transportation Districts One and Seven Transit Facility Handbook)

- Generally, stops should be located at the far side of an intersection to facilitate bus and traffic operations. However, far-side stops are occasionally impractical or conflict with existing development. Specific attributes of potential transit stops must be reviewed. Sight distance is critical. Transit drivers need to be able to see to the rear sufficiently to safely re-enter traffic, following vehicles need to see the stopped bus in time to safely stop or merge left, and vehicles on side streets or driveways need to be able to see oncoming traffic (Grand Junction/Mesa County MPO Transit Design Standards and Guidelines 2003).

- Near-side stop – use in combination with a far-side stop if transfer activity shows strong directional pairing to minimize pedestrian crossings. Far-side stop – use when there is a high volume of right turns OR the route alignment requires a left turn (stop is after the left turn) OR at complex intersections with multi-phase signals or dual right/left turn lanes. Mid-block stop – use when the route alignment requires a right turn and the curb radius is short (Transit Authority of River City - Transit Standards Manual: A Reference Guide 2006).

- Bus stops at intersections should be located in the safest position, considering traffic and street conditions. Where possible, stops should be located close to signalized intersections (York Region Transit – Transit Service Guidelines 2006).

- Far-side stops are preferable where buses can pull out of the main traffic lane and maneuver to the curb. Near-side stops are preferable where traffic is heavier on the leaving side than on the approaching side of the intersection. Mid-block stops should be avoided unless block-faces are long or unless stops serve a major trip generator (Service Evaluation & Performance Measurement Program - Madison Metro 2000).

- Bus stops should be located as close to the corner as possible to facilitate transfers and promote safe pedestrian crossings. Location on the far side of the intersection is standard (Valley Metro Performance Criteria and Service Standards 1999).

Bus bays or turnouts are another consideration when designing the location of stops. The decision to place a bus stop off-street in a turnout should be made carefully. Off-street turnouts allow buses to pull out of the traffic stream. Turnouts should not be located where there are potential rear-sight distance problems. Bus bays should be considered for stops located near major trip generators, transfer points, timing points or anywhere else where a bus is likely to have an extended stop or layover time.

Other ***stop location standards*** involve the interaction with roadway infrastructure and visibility/safety issues:

- Stop locations should minimize the potential for jaywalking while minimizing rider walking distance and avoiding unnecessary crosswalk movements. Stops on both sides of a two-way street should be paired up whenever possible to provide passengers with boarding and alighting points near one another (Grand Junction/Mesa County MPO Transit Design Standards and Guidelines 2003).

- The location of bus stops should also consider the future placement of passenger shelters/benches, and compliance with ADA. (Line Service Design Standards - VIA Metropolitan Transit, 2000)

The Transit Authority of River City had the following standards concerning stop location in its Transit Standards Manual: A Reference Guide (2006):

- Keep at least one exit and entrance driveway open for vehicles to access the site while a bus is loading/unloading passengers.

- Locate the stop to allow visibility for vehicles leaving the site and minimize vehicle/bus conflicts.

- Bus stops should not be placed in proximity of driveways or curb cuts unless absolutely necessary.

Bus stop spacing is the distance between adjoining service stops on a route. Transit operators have developed standards regarding bus stop spacing as part of their efforts to balance the trade-off between rider convenience (stops with short walking distances) and vehicle speed. Bus stop spacing has a major impact on the performance of a transit system. Stop spacing affects the overall travel time and, as a result, the demand for transit.

Bus stop spacing standards are typically measured in one of two ways and sometimes both – the number of stops per mile and/or the distance in feet between stops. The standard spacing, no matter what measure is used, can vary based on land use type, population density, or service type. Furthermore, the sample standards tend to include a range of values and do not specify an exact spacing. Because of these variations, bus stop spacing standards tend to act as guidelines and not hard and fast rules.

Examples of ***bus stop spacing standards by land use***:

- For established stops in urban areas, the minimum spacing is 500 feet; for new routes, the minimum is 1000 feet. For stops in suburban areas, the minimum spacing is 500 to 1000 feet. For stops in rural areas, the minimum spacing is 1500 feet. (Suburban Transit Division Service Standards and Process – SEPTA, 2004 revised)

- For the central core/CBD, the stop spacing should be 300 to 1000 feet; a typical spacing is 600 feet. For urban areas, the stop spacing should be 500 to 1200 feet; a typical spacing is 750 feet. For suburban areas, the stop spacing should be 600 to 2500 feet between stops; a typical spacing is 1000 feet. For rural areas, the stop spacing should be 650 to 2640 feet; a typical spacing is 1250 feet (Palm Tran Service Guidelines 1999).

- In the Grand Junction/Mesa County MPO Transit Design Standards and Guidelines (2003), recommended ranges for bus stop spacing are 500 to 800 feet for major commercial areas, 700 to 1000 feet for urban areas, and 1000 to 1500 feet for suburban areas.

- Bus stops are placed anywhere from 600 to 1250 feet apart, with additional stops placed at major activity centers (Transit Authority of River City - Transit Standards Manual: A Reference Guide 2006).

- No more than eight and no less than four stops per route mile will be provided along all line service routes, except express and limited stop routes outside the CBD. Inside the CBD, the provision of stops will be at the discretion of the Bus Operations Department based on boarding activity (Line Service Design Standards - VIA Metropolitan Transit 2000).

- Bus stops are normally located at major cross-street intersections and/or traffic generators. In most instances, stops will be about 1/8 mile apart (a standard Chicago block) and no longer than 1320 feet apart, except when pedestrian access is not provided (Chicago Transit Authority Service Standards 2001).

- Bus stops should be placed at most intersections, passenger generators, and transfer points subject to minimum spacing criteria. The spacing of stops should not normally be less than 250 meters (820 feet) in developed areas and 500 meters (1640 feet) in undeveloped areas (York Region Transit – Transit Service Guidelines 2006).

Example of ***bus stop spacing standards by population density***:

- For densities of more than 4,000 persons/ square mile, there should be 8 to 10 stops per mile or 500 to 700 feet between stops. For 2,000 to 4,000 persons/square mile, there should be 5 to 8 stops per mile or 700 to 1000 feet between stops. For densities less than 2,000 persons/square mile, 3 to 5 stops per mile or 1000 to 1500 feet between stops is sufficient. (FTA Introduction to Transit Workshop 1997)

Examples of ***bus stop spacing standards by service type***:

- Due to the need for higher speeds and service to park-and-ride facilities, express service will generally have stops spaced no closer than one mile apart and should have a minimum of three miles of closed door service (Palm Tran Service Guidelines 1999).

- Express service is exempt from stop spacing standard (Suburban Transit Division Service Standards and Process – SEPTA 2004 revised).

- Stop spacing for local services should be between 600 and 1200 feet (two to three blocks) (Milwaukee County TDP 2005-2009).

- The historical industry standard for spacing between bus stops is 750 to 800 feet on a local service line (Line Service Design Standards - VIA Metropolitan Transit 2000).

- Four to five stops per mile should be provided for local service and two to three stops per mile for feeder service (City of Folsom Short Range Transit Plan Update 2005).

- Core and Circulator routes should have stops spaced at 1320 feet (0.25 mile) or less. Peripheral routes should have stops spaced from between 1320 feet (0.25 mile) and 2640 feet (0.5 mile) (Service Evaluation & Performance Measurement Program - Madison Metro 2000).

- The RTD in Denver combined both land use and service type to determine its service standards for bus stop spacing:

Type of Service	Distance between stops (feet)		Stops per mile	
	Minimum	Maximum	Minimum	Maximum
Local routes in residential areas	600	1,250	4	8
Commercial areas	500	1,250	4	10
Limited stop zone	2,500	8,000	0.75	2

I-C Travel Time and Capacity

Travel time and capacity standards provide guidance on the schedule design functions of a transit system. Standards for this category address **service frequency**, **service directness**, **loading standards**, and **span of service**.

Service frequency refers to how often buses arrive at a particular stop. Headways refer to the interval in minutes between two successive bus departures. The terms are often used interchangeably. There are three different aspects to consider when setting headways for transit: headways based on **policy**, headways based on ***demand***, and headways based on the ***clock-face***.

Policy headways are headways that are defined by transit system policy and are usually modified by time of day or day of the week. They are typically used when passenger loads are light enough to require time intervals in excess of 10-15 minutes between vehicles to conform to loading standards.

Time of day is a predominant factor in determining varying headway intervals. The common practice is to have more frequent service during peak hours and less frequent service during off-peak hours. A

widely used policy headway is 30 minutes during peak hours and 60 minutes during off-peak hours. Headways for night, Saturday, and Sunday service usually match the off-peak headways or may be even longer.

Some sources state that 30-minute peak service is the minimum level at which urban transit provides an adequate level of basic mobility in a dense urban area. Service levels below 30 minutes (i.e., longer than) are generally unacceptable from the perspective of the passenger and are not enough to develop a solid, consistent, base of ridership. Base, evening, and weekend service should not exceed 60 minute headways.

Policy service levels represent a compromise between economic efficiency and the functionality of the system. Existing services that cannot meet the policy headways while adhering to the minimum passengers per hour or trip standards should be identified as candidates for service changes or appropriate marketing promotion within available resources. These service changes may include providing service with longer headways if no other viable alternative exists.

Policy headways can also be altered by the type of service. Bus Rapid Transit will typically have shorter headways (10 to 15 minutes), while community-based circulators tend to have longer intervals (60 to 120 minutes).

Demand-based headways are established to provide a sufficient number of trips to accommodate the maximum passenger volume within the loading standards. Demand-based headways are typically used only when service demand requires less-than-30-minute service intervals. Overcrowding of buses on a route is a sign that either larger vehicles need to be used or a demand-based headway should be instituted to increase the overall capacity of the route.

Clock-face headways refer to setting headways to intervals that divide evenly by 60. For example, 12- or 15-minute schedules are used, but 13 or 17 minutes are not used. For use with policy headways, it is highly recommended and common practice to use clock-face headways. However, using clock-face headways in conjunction with demand-based headways at intervals greater than every 10 to 12 minutes is somewhat controversial in the transit industry. Clock-face headways help passengers better predict bus arrival times at stops and eliminate the need for complex schedules, thus allowing passengers to be less dependent on time-tables. User-friendly clock-face headways are more attractive to riders; however, from the cost-accounting viewpoint; it may be more expensive to write schedules around this criterion.

Special considerations that agencies have concerning clock-face headways include the following:

- When possible, where headways are 10 minutes or greater and where efficient scheduling will allow, clock-face headways (10, 15, 20, 30, and 60) should be utilized (Palm Tran Service Guidelines 1999).

- If possible, the operation of clock headways should be maintained to facilitate transfers between lines. When clock headways are operated on lines that connect, coordination of transfers between these lines is made easier (Line Service Design Standards - VIA Metropolitan Transit 2000).

- Service frequency in the RTD network is based on "clock pattern" schedules. This pattern provides consistent and easy-to-understand schedules for the customers and makes possible the provision of timed transfer connection hubs. In general, routes are scheduled to operate in even increments of 30 minutes or every 5, 7.5, 10, 15, 30, or 60 minutes. However, other frequencies may be provided depending upon passenger demand or operational and scheduling needs. (Service Standards - RTD [Denver, CO] 2002)

- In all cases of service frequencies exceeding 15 minutes, the schedule should be written on clock, memory-based headways so that the service always is scheduled at the same time each hour (AC Transit Service Standards and Design Policy 2004 revised).

- Clock-face headways are recommended for frequencies greater than 10 minutes (York Region Transit – Transit Service Guidelines 2006).

Service directness refers to the degree to which a route deviates from the shortest path between the start and end points of the route. Service directness has an inverse relationship to service coverage, as a route that deviates provides greater coverage at the expense of directness, while a more direct route provides less coverage. Agencies often provide standards for service directness, so that routes operate as directly as possible to maximize average speed and minimize travel time.

Agencies approach service directness standards using several different methods. One such method is to set a standard based on the ***ratio of transit route distance to highway route distance*** as shown in the following examples:

- Service will be provided with a transit route distance divided by highway route distance of no higher than 1.5 (FTA Introduction to Transit Workshop 1997).

- Transit travel distances should not exceed auto travel distances for the same trip by more than 20 to 40 percent (TCRP Synthesis 10 – Bus Route Evaluation Standards 1995).

- Routes should not be more than 50 percent longer in route mileage distance than a comparable route by car (Service Evaluation & Performance Measurement Program - Madison Metro 2000).

Another method that is used to set standards for service directness is to ***limit the time spent for deviations to the main service***. When considering a deviation, the gain in convenience for those passengers who are boarding or alighting during the deviation must be balanced against the additional travel time for the other passengers. In these cases, formulas have been developed that measure the impact of additional time in the schedule versus additional ridership gained by making a deviation. Example standards for time spent for deviations include:

- Route deviations will not exceed eight minutes roundtrip and will only be permitted if the market potential is 10 passengers per roundtrip (Service Policy for Surface Public Transportation - Massachusetts Bay Transportation Authority, 1975).

- Some standards limit deviations to a maximum number of minutes (five to eight) of additional travel time for a one-way bus trip (TCRP Synthesis 10 – "Bus Route Evaluation Standards" 1995).

- Deviations from a direct path from end-to-end of the route shall account for no more than ¼ of the end-to-end travel time of the route (Service Standards - RTD [Denver, CO] 2002).

- For a specific deviation, the total additional travel time for all through passengers should not exceed three minutes for each rider boarding or alighting along the deviation (Service Standards - RTD [Denver, CO] 2002).

- Route deviations must attract enough new passengers to the route (not merely reduce the walking distance for existing passengers) to make the change worthwhile. For example, if the additional travel time means more service hours need to be added, the change should be made only if it improves the overall performance of the route (York Region Transit – Transit Service Guidelines 2006).

- If the deviation can be achieved with the existing resources (typically less than two minute increase in running time), the new ridership gained should be no less than 25 percent of the passengers affected by the deviation (York Region Transit – Transit Service Guidelines 2006).

- Requests for a deviation will be evaluated using the following formula: number of current passengers multiplied by the additional vehicle one-way travel time divided by the number of

passengers served by the deviation. If the result is less than five minutes, the deviation is acceptable (Palm Tran Service Guidelines 1999).

Another standard used is based on the ***ratio of transit route travel time to automobile travel time,*** as shown in the following examples (note that the ratio can vary by service type):

- Travel for public transit passengers should be reasonable in comparison to travel by private auto for trips made between component parts of the service area. Transit travel distances and times should not be more than 1.5 times longer than with the auto. (Milwaukee County TDP 2005-2009)

- Bus travel should be as time-competitive as possible with private auto travel in order to provide attractive and convenient service. Peak period transit travel times between major origin-destinations (O-D) should be as close as possible to the comparable travel time by private auto and not to exceed 1.75 for major radial lines, 2.00 for minor radial lines, 1.25 for limited stop routes, 1.15 for express routes, 1.50 for cross-town routes, and 2.00 for circulator routes. The comparable travel time is the time the patron is on the bus and does not include wait or transfer time (Line Service Design Standards - VIA Metropolitan Transit 2000).

- Transit travel time for a one-way trip from origin to destination (including transfers) should take no longer than three times the equivalent auto trip during peak commute times (City of Folsom Short Range Transit Plan Update 2005).

- Each route type has a range for this standard based on a ratio. Base routes and BRT range from 1.0 to 1.1 of auto travel time, local routes range from 1.0 to 1.2, express routes should match auto travel, shuttle services range from 1.25 to 1.75, and community bus must be less than 2.5 (York Region Transit – Transit Service Guidelines 2006).

Another measure of service directness is the ***number of transfers required for a passenger to reach his final destination***. The more transfers required in a system, the longer total travel time will be, as additional wait time must be factored in. Systems try to reduce the overall wait time for transfers by coordinating bus schedules to reduce wait times at key transfer locations (also known as timed transfers). Some agencies even set standards that

Measures for Service Directness

Ratios/Deviations
- ***Ratio of transit distance to highway distance***
- ***Ratio of transit travel time to auto time***
- ***Limitations on time spent for deviations***

Transfers
- ***Maximum transfer rate***
- ***Maximum time for arrivals and departures***

the overall transfer rate (the percentage of trips that require a transfer) will be limited to a certain percentage.

Examples of standards for coordinating schedules and setting transfer rates include:

- Transfers between buses should be as convenient as possible, and efforts should be made to reduce patron travel time. Cross-town and circulator line schedules should be designed to facilitate transfers to and from intersecting or connecting radial line service. Circulator service should be scheduled to arrive no more than 10 minutes before the departure of express buses and depart no more than 10 minutes after the arrival of express buses (Line Service Design Standards - VIA Metropolitan Transit 2000).

- Schedules should be coordinated for direct transfer to the extent possible at transfer points (Service Evaluation & Performance Measurement Program - Madison Metro 2000).

- Extra care will also be exercised to coordinate connections at transfer points located in areas with less service coverage in order to compensate for the lower number of transfer possibilities (Valley Metro Performance Criteria and Service Standards 1999).

- No more than 25 percent of transit customers should require more than one vehicle to complete their trip (Service Policy for Surface Public Transportation - Massachusetts Bay Transportation Authority 1975).

- Direct local service must be made to 70 percent of riders and express service to 80 percent of riders (FTA Introduction to Transit Workshop 1997).

A popular practice agencies use to reduce the amount of transfers is called ***interlining***. Where two separate routes have a common transfer location and that specific pair of routes result in a large number of transfers, those two routes are candidates for interlining. Interlined buses operate on both routes, allowing passengers to remain onboard. For two routes to be potential candidates for interlining, frequencies and hours of service on each route should be nearly identical, and combined run time should not exceed four hours. An example standard would be that if the transfer rate is 20 percent or higher between two routes, then they are potential candidates for interlining.

Finally, coordination of schedules is also important when dealing with the ***regional connectivity*** the transit system has with other systems or modes of travel. A set of standards that govern the various responsibilities of all parties to ensure convenient transfers and adequate passenger facilities at the transfer location is critical.

Loading standards are created to maintain acceptable passenger loads onboard buses. Passenger loading limits have a direct correlation with headways – if buses are overcrowded, then additional service may be warranted, resulting in shorter headways. Another option to increase capacity is to operate larger buses.

The ***load factor*** is an indicator of the extent of probable overcrowding or the need for additional vehicles. It is expressed as a percent of the seating capacity of a vehicle at the maximum load (busiest) point of a particular route. For example, if a service operates at 15-minute intervals, then four buses would pass the busiest point in an hour. The average number of passengers for those four buses must fall within the service standards, even though one bus may be more crowded than the average.

By establishing ***minimum and maximum load factors*** for different services by service periods, the level of service or headway that should be operated is determined by usage. Load factor calculations are the primary variable used to assess how buses can be effectively and efficiently allocated among different bus routes. If the load factor is set above 100 percent, it means that the system's policies permit a reasonable amount of standees.

Example loading standard guidelines include:

- At no point should the load factor for a single trip be greater than 175 percent. Average maximum loading guidelines range from 100 to 140 percent based on headways and time of day (Palm Tran Service Guidelines 1999).

- During peak periods, the load factors range from 120 to 140 percent, while it is set at 100 percent during the non-peak periods. (Service Policy for Surface Public Transportation - Massachusetts Bay Transportation Authority, 1975).

- The load factor is 100 percent for non-peak service and 125 percent for peak service (FTA Introduction to Transit Workshop 1997).

- The average maximum load factor should not exceed the following during any one-hour period: 133 percent during peak periods and 100 percent during non-peak periods. Rapid services should never exceed 100 percent (Milwaukee County TDP 2005-09).

- The total passenger load on any line during any 60-minute interval should not exceed 125 percent of seated capacity. In addition, the passenger load on any individual bus should not

exceed 150 percent of the seated capacity (Line Service Design Standards - VIA Metropolitan Transit 2000).

- The peak maximum load is set to 125 percent of capacity. Off-peak, express, and regional routes shall have a load factor of 100 percent. Service frequencies should be adjusted so that the following maximum load standards are met at least 60 percent of the time (Service Standards - RTD [Denver, CO] 2002).

- The vehicle load thresholds are 125 percent for all services except for express and owl services, which are 100 percent (AC Transit Service Standards and Design Policy 2004 revised).

- Local service has a load factor of 125 percent in the peak; all other types and times have a load factor of 100 percent. The maximum load should not exceed 145 percent (Valley Metro Performance Criteria and Service Standards 1999).

Another loading standard that may be used is a ***policy that limits the number of standees or does not allow for standees*** (15 percent of respondents in the TCRP Synthesis 10 survey have a no-standee policy). Additional standards might limit the time spent standing, although this requires ride checks and may be difficult to measure. The following standards have been applied at some agencies:

- On regular bus routes, no standees are allowed, and load factors should average less than 100% percent to allow for ridership growth and because of longer travel times (Service Policy for Surface Public Transportation - Massachusetts Bay Transportation Authority 1975).

- A typical bus will have between 50 to 60 passengers on board, which include 10 to 20 standees (Chicago Transit Authority Service Standards 2001).

- Standees are limited during peak periods permitted according to a chart. The percent of maximum capacity ranges from 125 to 169 percent, depending on the type of vehicle operated (Suburban Transit Division Service Standards and Process – SEPTA 2004 revised).

- During non-peak periods, the objective is to seat each passenger. However, when standee conditions exist during non-peak periods, incidents are considered tolerable when passenger standee time does not exceed 15 minutes on a consistent basis (Suburban Transit Division Service Standards and Process – SEPTA 2004 revised).

- Emphasis should be given to avoid standees on buses when traveling on expressways (Line Service Design Standards - VIA Metropolitan Transit 2000).

- Limit standees to a maximum of 20 percent of daily runs (City of Folsom Short Range Transit Plan Update 2005).

- If the maximum load standing consistently exceeds the established threshold, and these passengers are standing for periods of greater than 15 minutes, corrective action would be taken to resolve these conditions (Suburban Transit Division Service Standards and Process – SEPTA 2004).

Measures for Loading Standards

- ***Load factor***
- ***Maximum passenger loads***
- ***Maximum standees***
- ***Duration of standee time***

- The maximum time that a passenger should be expected to stand on a given trip is 15 minutes (Service Standards - RTD [Denver, CO] 2002).

Span of service is another measure that relates to the capacity of the system. **Span of service is the number of hours and days when service operates**, i.e., the start of the service day until the end of the service day, as well as weekdays, Saturday, and/or Sunday. The longer period of time that service is available, the greater is the capacity of the system. The span of service will usually vary by route depending on service type, the day of the week, and route performance. Generally, high-performing routes will have longer service spans, and weekday spans of service are longer than for Saturday and Sunday. Express routes generally operate a time-specific span of service (weekday AM and PM peak periods is standard), though demographic characteristics and work hours of the area may require a different span of service.

For determining span of service for new routes, the characteristics of the target market should be examined and compared to existing services. When considering changes in the span of service of a route, the following examples show how the changes can be applied:

- When considering changes in a route's service start or finish time, an earlier or later trip should be considered if the first or last trip of the existing service is performing better than 50 percent of the system average in passengers per revenue hour (Palm Tran Service Guidelines 1999).

- Span of service extensions are considered when the hour immediately before the end of the current service or after the beginning shows productivity greater than the average system productivity for that hour. They are also considered when new or revised employee shift changes or extension of business hours create a new demand for service (Chicago Transit Authority Service Standards 2001).

Weekend and holiday service is another option for which a bus agency may set standards. Weekend and holiday service can enhance the attractiveness of weekday service and positively affect system ridership by providing that weekday riders need not seek alternative modes on the weekend. However, it typically does not have the same level of ridership performance that occurs on the weekday, and therefore is less cost effective. An example standard for setting the span of weekend service is:

- Service span will be based on the utilization of daily service with additional justification provided through market research. Saturday service will not be implemented until the market research indicates the potential for this service to meet or exceed 50 percent of the average daily passengers per hour for the line specified. Sunday service should not be implemented until the Saturday passengers per hour exceed 75 percent of the service category average (Line Service Design Standards - VIA Metropolitan Transit 2000).

- Weekend service may be provided on lines that serve locations which have a high level of weekend activity irrespective of the daily weekday ridership (Line Service Design Standards - VIA Metropolitan Transit 2000).

I-D Service Delivery

Service delivery standards involve the direct impact on the customers and how they perceive the service. They include such aspects as **on-time performance, passenger shelters and other amenities, customer service, and safety issues.**

Measures for On-Time Performance

- ***Percent on-time***
- ***Minutes early/late***

On-time performance in the transit industry is defined as the percentage of trips that arrive/depart within a specified time frame at a specific published time point. A majority of systems define a route as being late if it is late over five minutes (but some systems have stricter guidelines). Most systems define a route as early even if it is one minute early, while a few systems allow for a bus to be earlier without considering it early. Examples of on-time performance standards throughout the industry include:

- Palm Tran defines “on-time” as arriving from one minute early to five minutes late. The goal is 90 percent on-time during peak service and 95 percent all other times (Palm Tran Service Guidelines 1999).

- On-time is defined as 0-5 minutes late. Percent on-time standard is set at 80 percent for headways less than 10 minutes, and 95 percent above 10 minutes. Peak service is set at 75

percent less than 10 minutes and 85 percent above 10 minutes (FTA Introduction to Transit Workshop 1997).

- On-time is defined as 0-5 minutes late; running ahead of schedule is not considered acceptable schedule adherence. During peak hours and for headways less than 10 minutes during peak hours, 75 percent of trips must be on-time; for headways above 10 minutes, 85 percent of trips must be on-time. During non-peak hours and for headways less than 10 minutes, 80 percent of trips must be on-time; for headways above 10 minutes, 95 percent of trips must be on-time. (Suburban Transit Division Service Standards and Process – SEPTA 2004 revised).

- The transit system should be designed and operated to maximize schedule adherence and be "on-time" at least 90 percent of the time. On-time is defined as within the ranges of one minute early to three minutes late (Milwaukee County TDP 2005-09).

- A trip is considered on-time by arriving no more than 0-5 minutes late. Trips arriving at a scheduled time point less than 30 seconds early will be considered on-time only if they do not depart the location ahead of their scheduled time. On-time performance is not affected by trips that arrive early at the end of the line. The percentage of on-time trips at official time points (except where layover is scheduled, then leaving times will be used) should not fall below the following: end of line – 95 percent, transfer points – 90 percent, all other time points – 85 percent (Line Service Design Standards - VIA Metropolitan Transit 2000).

- On-time is defined as not early and no more than three minutes late. This standard must be met 95 percent of the time for local routes and 90 percent of the time for flexible routes (City of Folsom Short Range Transit Plan Update 2005).

- The MBTA has established on-time performance thresholds for all its services based on arrival times. Buses are considered on-time if they arrive less than two minutes early or less than five minutes late. A bus route meets the performance standard if it is on-time 75 percent of the time when headways are greater than 10 minutes, and 85 percent of the time when headways are less than 10 minutes. For peak period travel times, the measure is 60 percent. BRT has a 95 percent on-time standard (Transit Performance Measures – Boston MPO 2004).

- A total of 95 percent of sampled trips should be no later than five minutes, and no service should operate ahead of schedule (Valley Metro Performance Criteria and Service Standards 1999).

The location of **passenger shelters and associated amenities** is another area of service delivery that benefits from having standards. Every system should strive to place its shelters and amenities in the locations that will create the greatest benefit for its customers. Generally, this occurs at the stops that have the highest utilization, but other factors may be considered. Examples of standards associated with the placement of passenger shelters and amenities are:

- The Florida Department of Transportation Transit Office have sponsored two research efforts that focus on the design and planning for transit facilities that address a wide range of subjects related to transit service planning, including suggested standards and guidelines for bus shelters and amenities. (refer to References section of this report for the reports – Accessing Transit Version 2 and Florida Department of Transportation Districts One and Seven Transit Facility Handbook)

- Passenger shelters should be provided at all bus stops where warranted by existing conditions, including boarding passenger counts, passenger wait time, bus stop situation, exposure to weather conditions, and the facility or land use being served (Milwaukee County TDP 2005-09).

- Shelters should be considered at the following locations: any stop serving more than 40 boardings/transfers per day within major commercial areas; any stop serving more than 25 boardings/transfers per day within urban or suburban areas; any stop that is a major transfer point between routes; or any stops located near schools, senior citizen housing facilities, or community recreation centers where large concentrations of the young and elderly are expected (Grand Junction/Mesa County MPO Transit Design Standards and Guidelines 2003).

- The primary factor in the placement of benches and shelters should be the number of boardings that occur at a location. Other considerations may be the average wait time between buses, number of bus lines, elderly and handicapped facilities, or protection from weather elements (Line Service Design Standards - VIA Metropolitan Transit 2000).

- Priority factors for selecting bus stops as candidates for shelters include all terminals and transfer points, high boarding locations (35 pas/hour in peak periods), unique exposure to inclement weather, and in front of senior residences and other institutional facilities (York Region Transit – Transit Service Guidelines 2006).

- Shelters should be provided at all transit stops serving 15 or more passengers per day; seating should be provided at all transit stops serving 5 or more passengers per day (City of Folsom Short Range Transit Plan Update 2005).

- The placement of shelters and bus stop amenities is determined based on threshold values of daily passenger boardings. Seating is standard for 50+ daily boardings and, typically, a shelter will require at least 100 daily boardings. Lighting, route info and expanded sidewalks also require at least 100 daily boardings (Palm Tran Service Guidelines 1999).

- Priority for amenities is given to stops that have a large number of passengers boarding, lengthy wait times, a high percentage of transfers, and a high percentage of seniors/disabled using it (Chicago Transit Authority Service Standards 2001).

- Amenities are based on the following – high boarding count or transfer location, special needs (seniors, medical offices), activity location, exposure to elements, long waiting time for the bus, distribution of improvements, and requests (Valley Metro Performance Criteria and Service Standards 1999).

- Information including bus route, numbers, schedule information, transit riding tips, and other appropriate information should be supplied at all stops (Grand Junction/Mesa County MPO Transit Design Standards and Guidelines 2003).

Some sites that would otherwise make a good bus shelter location may not accommodate a shelter due to physical limitations. The following example standards address the placement of shelters:

- The feasibility of installing a shelter will be determined by site-specific physical limitations and easements (Service Policy for Surface Public Transportation - Massachusetts Bay Transportation Authority 1975).

- All bus stops will be considered for a passenger shelter or bench provided there is available space and the physical features of the area will allow for installation and safe access (Line Service Design Standards - VIA Metropolitan Transit 2000).

- Shelter placement is also dependent upon the agreement of affected property owners and compliance with local government ordinance, building codes, and ADA requirements (Line Service Design Standards - VIA Metropolitan Transit 2000).

Measures for Passenger Shelters/Amenities

- ***Boarding/transfers at stops***
- ***Average wait time***

Adequate lighting at stops and shelters is an important safety component, and an agency may have standards governing lighting. The following are examples of lighting standards:

- Passenger safety is enhanced by adequate lighting. Direct illumination of waiting passengers by a streetlight allows the transit driver to easily see them. Supplemental lighting shall be provided at shelters in accordance with the applicable zoning and development code requirements (Grand Junction/Mesa County MPO Transit Design Standards and Guidelines 2003).

- Proper lighting is important for safety and security of transit patrons. Shelters should be well lit when it is dark outside or when existing street lights do not provide adequate lighting. (Transit Authority of River City - Transit Standards Manual: A Reference Guide 2006)

Customer service standards are limited to what can be easily measured by the transit agency.

Performance measures that are most often used to measure the level of customer service are the ***number of complaints***.

An example standard for number of complaints is:

- Passenger complaints shall be less than 1 per 5,000 passengers. Management response should be provided to all complaints within one working day (City of Folsom Short Range Transit Plan Update 2005).

Measures for Customer Service/Safety

- ***Complaints***
- ***Rate of accidents***

Other customer service concerns such as the passenger environment and passenger satisfaction are determined based on passenger surveys. Agencies are not likely to have specific standards governing these more qualitative factors.

Safety Issues are another area in which an agency is likely to keep performance measures and set standards. Safety performance measures are usually kept on a system level and may not be available at the route level. Service planning may have only a small role to play in safety-related standards.

The most common safety measure tracked by transit agencies is the ***number of accidents per miles operated***. Example standards include:

- No more than 6 accidents may occur per 100,000 miles operated (FTA Introduction to Transit Workshop 1997).

- The number of accidents should be minimized (accidents per 100,000 vehicle miles). (Milwaukee County TDP 2005-09).

- The rate of accidents (as defined by FTA) should not exceed 20 accidents per 1,000,000 miles (Line Service Design Standards - VIA Metropolitan Transit 2000).

- The transit system should maintain a minimum of 100,000 miles between preventable collision accidents (City of Folsom Short Range Transit Plan Update 2005).

- The rate of accidents per 100,000 vehicle miles should not exceed the previous year's total for the system (Valley Metro Performance Criteria and Service Standards 1999).

I-E Vehicle Standards

Vehicle standards address the various service planning aspects of operating transit vehicles such as the **assignment of vehicles, utilization and efficiency, and reliability and condition**.

The **assignment of vehicles** is fairly straightforward. In a medium-sized or larger system, standard-sized buses (35 - 40 foot) are assigned to most routes, while smaller buses (27 - 30 foot) may be used in areas with fewer riders or in neighborhood service. Articulated buses (60 foot) are appropriate for higher volume limited and express services. They are also used with Bus Rapid Transit (BRT) services. Smaller systems may incorporate only smaller buses.

Systems that use automatic passenger counters (APC) on a portion of their fleet will also have specific procedures on how to assign APC-equipped buses in order to cover all routes within a specified time period.

Vehicle utilization and efficiencies are typically tracked in a performance monitoring program. The most common measures are ***revenue miles/per vehicle and revenue hours/per vehicle***, but agencies may also set separate standards.

The ***spare ratio,*** which measures the ratio of vehicles in the fleet above what is required to operate the service in the peak period (maximum service), may also be subjected to standards.

An example of a spare ratio standard from the Minnesota DOT:

- Extra vehicles beyond a system's optimal need should be minimized to control capital and maintenance costs. The number and type of vehicles should be sufficient to handle trip demand and include a spare ratio to ensure minimal disruption of service. If there are 2 - 10 regular

vehicles in maximum service, 1 spare is needed; for 11 - 20 vehicles, 2 spares are needed. For every 10 beyond 20 vehicles, an additional spare is required.

Deadhead miles measure the number of miles vehicles travel from the garage to the point that they enter service. The literature search did not reveal any specific standards for deadhead miles (expressed as the percent of deadhead miles to total run miles), but it was referred to in the Triangle Transit Authority's Regional Bus Service Standards (2003) as an important consideration to track in its performance measures.

Another measure of vehicle efficiency is ***layover time versus running time***. Layover time is defined as the amount of time drivers spend waiting at the end of the line. Running time is the amount of time the bus is in service. An example standard might be that a route having a layover to running time ratio of greater than 20 percent should be evaluated for potential schedule modifications.

Another potential measure of efficiency is ***fuel efficiency,*** which is typically measured by vehicle miles per gallon of fuel. While this is a trackable performance measure, service planning departments generally do not impose standards for this measure since it is a function of the fleet composition and is outside the scope of service planning.

Other vehicle issues include **vehicle reliability and condition**. Vehicle miles between road calls is a common measure of vehicle reliability.

Example standards for this measure include:

- Minimum of 10,000 revenue miles for each service disruption due to mechanical failure allowed. (Service Policy for Surface Public Transportation - Massachusetts Bay Transportation Authority 1975).

- Minimum of 4,000 vehicle miles between road calls allowed. (FTA Introduction to Transit Workshop 1997)

- The number of breakdowns requiring a maintenance road call should not exceed 6,000 vehicle miles of service (Milwaukee County TDP 2005-09).

Measures for Vehicle Standards

Utilization and Efficiency

- ***Vehicle miles per vehicle***
- ***Revenue miles per vehicle***
- ***Revenue hours per vehicle***
- ***Spare ratio***
- ***% of deadhead miles***
- ***Layover versus running time***

Reliability/Condition

- ***Vehicle miles between service disruptions (road calls)***
- ***Average age of fleet***
- ***Service life***

- Maintain a minimum of 10,000 miles between road calls (City of Folsom Short Range Transit Plan Update 2005).

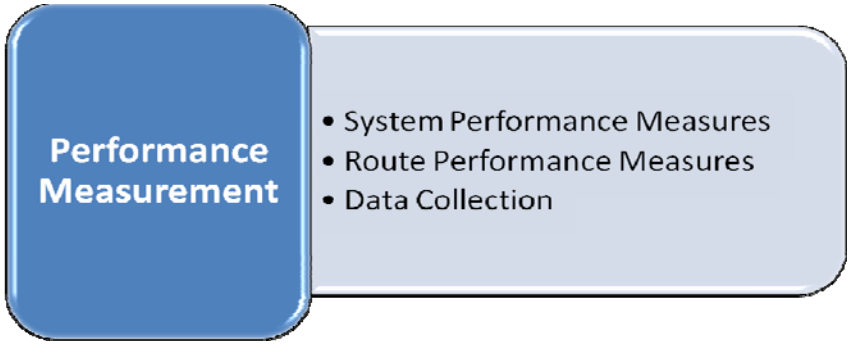
Average age of the fleet and ***service life*** measure the condition of the fleet. The average vehicle age is a common performance measure that is calculated by averaging the ages of all vehicles in the fleet. Service life defines the normal useful life of a vehicle before it will require either major rehabilitation or replacement. Tracking the useful life of the vehicle fleet is essential for planning purposes and for determining future bus replacement schedules.

The following service life measurements, from the Milwaukee County TDP, were originally taken from FTA guidelines:

- Heavy-duty bus (35 foot or longer) – 12 years or 500,000 miles
- Heavy-duty bus (25 - 30 foot) – 10 years or 350,000 miles
- Medium-duty bus (25 - 30 foot) – 7 years or 200,000 miles
- Light-duty bus (25 - 30 foot) – 5 years or 150,000 miles

I-F Service Equity

Service equity refers to the equitable distribution of services for all population groups, especially minority populations. Title VI of the Civil Rights Act of 1964 governs service equity. It requires transit providers to develop service standards to assure that service is provided in an equitable, nondiscriminatory manner. At a minimum, FTA requires that transit service policies and standards be established for five specific items: vehicle load, vehicle assignment, vehicle headway, distribution of transit amenities, and transit access. Local transit providers may develop and operate their own additional standards (Line Service Design Standards - VIA Metropolitan Transit 2000).



Part II - Performance Measurement

Agencies collect performance measures at a system and individual route level for a variety of reasons. These reasons span all departments of an agency, from finance to planning to management, and even impact outside agencies such as the local Metropolitan Planning Organization and the Regional Planning Councils.

On a system level, performance measures are used to:

- submit to the National Transit Database as a requirement to receive funding from FTA
- assist agencies in monitoring the various trends of the agency for operational and financial measures and also to compare their performance versus other peer agencies
- define service design standards as described in Part I of this literature review

On an individual route level, performance measures are used to:

- perform a Comprehensive Operations Analysis (COA)
- define performance standards
- monitor performance to measure against the system average or defined standards

For the purpose of transit service planning, tracking performance at the individual route level enables transit planners to make good decisions concerning transit service. For this reason, this section describes the performance measures that are commonly used for this purpose.

II-A Route Performance Measures

Route performance measures are typically categorized as **operational measures** (i.e., ridership, service levels, etc.) or **financial measures** (i.e., operating expenses, financial ratios, etc.).

Measures for Route Performance

Effectiveness

- ***Passenger trips per hour***
- ***Passenger trips per mile***
- ***Passenger trips per vehicle trip***

Financial Efficiency

- ***Subsidy per passenger trip***
- ***Farebox recovery***

The productivity measure most often used by transit planners is ***passenger trips per revenue hour***. Its near universality is reflective of the fact that wages, typically 80 percent of an operating budget, are paid on an hourly basis. Most systems use "unlinked" passenger trips, essentially counting each time a person boards a bus as a trip. Therefore, transferring passengers make multiple passenger trips. Also used in performance monitoring, but less frequently, are ***passenger trips per revenue mile*** (useful for bus routes that make relatively frequent stops) and ***passenger trips per vehicle trip*** (typically used for express bus service with few daily trips).

Example standards for **operational performance measures** include the following:

- Local routes should average 25 passengers per hour with a minimum of 8 passengers per hour. Peak and off-peak performance targets are as follows: base and local routes should average 30 passengers per hour, with a minimum of 10 passengers per hour during peak hours, and average 22 passengers per hour, with a minimum 7 passengers per hour during off-peak hours. Express routes should average 30 passengers per hour, with a minimum of 10 passengers per hour. Shuttles should average 25 passengers per hour, with a minimum of 20 passengers per hour. Community buses should average 15 passengers per hour, with a minimum of 5 passengers per hour during peak hours, and average 12 passengers per hour, with a minimum 4 passengers per hour during off-peak hours (York Region Transit – Transit Service Guidelines 2006).

- The productivity guideline for fixed route service is 15 to 20 passengers per hour, and route deviation service should average 5 to 8 passengers per hour (Minnesota DOT Service Overview).

- The minimum ridership to warrant continued service is 22 passengers per hour for weekday service, 15 passengers per hour for Saturdays, and 10 passengers per hour for Sunday/Holidays (Milwaukee County TDP 2005-09).

- The standard for passenger trips per hour is 30 when the service interval is 30 minutes (Chicago Transit Authority Service Standards 2001).

- 25-39 passengers per hour is typical for service with 15 minute headways, and 40+ passengers per hour for service with 10 minute headways (Service Standards – RTD 2002).

- Minimum ridership productivity should average 12 passengers per hour on local routes, 20 passengers per hour on feeder service, and 6 passengers per hour on flexible routes (City of Folsom Short Range Transit Plan Update 2005).

- Boardings per revenue hour for 20 - 34 foot buses should meet the following standards: 20 passengers per hour during peak hours and 10 passengers per hour during off-peak hours. Boardings per revenue hour for 35 - 40 foot buses should meet the following standards: 25 passengers per hour during peak hours and 20 passengers per hour during off-peak hours. Boardings per revenue hour for articulated buses should meet the following standards: 38 passengers per hour during peak hours and 30 passengers per hour during off-peak hours (Valley Metro Performance Criteria and Service Standards 1999).

- A service must maintain the following passengers per mile averages: 2.5 passengers per mile during the peak period and 1.5 passengers per mile in the off-peak (Service Policy for Surface Public Transportation - Massachusetts Bay Transportation Authority 1975).

- The minimum passengers per mile are 2.5 for high frequency lines and 1.2 for low-frequency lines during the weekday. For Saturday, the minimums are 1.75 and 1.0, respectively (FTA Introduction to Transit Workshop 1997).

Common **financial performance measures** for transit include ***operating expenses per revenue hour, per revenue mile, and per passenger trip*****.** Except in rare occurrences, these specific measures are not commonly used for setting performance standards; rather, the more commonly used financial measures used to set performance standards are ***subsidy per passenger trip*** and ***farebox recovery ratio***.

Subsidy per passenger trip measures the funds necessary to make up the difference between cost per passenger and revenue per passenger. It is easier to explain this measure to the public than cost per passenger. Two to three times the system average is typically acceptable for subsidy per passenger on a route, as stated in TCRP Synthesis 10.

The ***farebox recovery ratio*** is the percentage of direct operating costs for a route that are recovered through the fares paid by the ridership. Most systems have a minimum standard for this measure. Example standards include:

- The revenue recovery for regular routes should be 30 percent, for premium services 50 percent, and for community-based services 20 percent (Service Policy for Surface Public Transportation - Massachusetts Bay Transportation Authority 1975).

- The standard farebox recovery should be 40 percent for urban routes and 25 percent for outlying routes. A percent of system standard is set at 67 percent and above being acceptable; for recovery factors of 50 percent to 67 percent, the route will be reviewed or modified; for 50 percent or less, the route requires major revision or elimination (FTA Introduction to Transit Workshop 1997).

- A farebox recovery goal of 20 percent is suggested for all service types (Minnesota DOT Service Overview).

- On an annual basis, routes will be ranked on an operating ratio basis from greater to lesser. The minimum standard is 60 percent of the average suburban transit operating ratio. A route performing below the minimum operating standard will be evaluated as a part of an Annual Service Plan. There are three exceptions to this standard: feeder routes, subsidized routes, and routes that provide the only service coverage for an area of the region. In the third case, an aggressive marketing campaign should be undertaken in an attempt to bring the route to minimum standards (Suburban Transit Division Service Standards and Process – SEPTA 2004 revised).

- To increase ridership and overall revenues, Palm Tran shall maintain a farebox recovery rate of 23 to 25 percent based on a strategy of reducing/eliminating bus routes with very low ridership, increasing bus service on remaining routes, and extending service to transit-attractive areas. Fare pricing can also have a major impact on farebox recovery and should be continually monitored (Palm Tran Service Guidelines 1999).

- The system wide minimum farebox recovery is 30 percent. If the standard is not met, several courses of action may be taken, including fare adjustments, marketing services more aggressively, or looking for revenue from other sources (Service Standards – RTD 2002).

- TTA Board and General Manager have set a goal of 25 percent Cost Recovery Ratio (Triangle Transit Authority – Regional Bus Service Standards 2003).

- The minimum farebox recovery ratio is set at 20 percent as required by TDA law. Feeder services must maintain a 30 percent farebox recovery, while flexible routes are allowed a 10 percent farebox recovery (City of Folsom Short Range Transit Plan Update 2005).

- The minimum farebox recovery should not be lower than 75 percent of the average for each route classification (Valley Metro Performance Criteria and Service Standards 1999).

- There are times when knowing the subsidy per passenger along with the farebox recovery ratio has important ramifications. A route where the cost recovery ratio and subsidy per passenger are declining means two things: more people are riding, but the bus is taking in less revenue. This can happen during promotional periods when many free passes are distributed. Also, if cost recovery is stable, a falling subsidy per passenger is a way to show that TTA is increasing the value of taxpayer money invested in the system (Triangle Transit Authority – Regional Bus Service Standards 2003).

II-B Data Collection

The tracking of route performance requires various kinds of data and methods of collection. The most widely-used and oldest method is that of **ride checks** or manual counts. This requires the use of a bus operator, a traffic checker, or a field supervisor who counts passengers as they board and exit the bus at each stop along a route. Ride checks can determine overall route usage, segment performance, and the validity of running-time specifications. Ride checks are also used to verify that vehicle load standards are not exceeded. The literature indicates that manual data collection produces minimal measurement errors. However, due to the small sampling size, it is subject to sampling error on a route-level basis, where the data collected on a single day may not represent overall operating conditions.

Farebox data can supply detailed information such as ridership by route and fare type. These data are useful for tracking data over time and for performance monitoring. Because fareboxes are typically installed on the entire fleet, it is possible to get regular, large-scale ridership information rather than the samples provided by other methods. However, this information is typically more aggregated (at the route level instead of the stop level) than available from other methods.

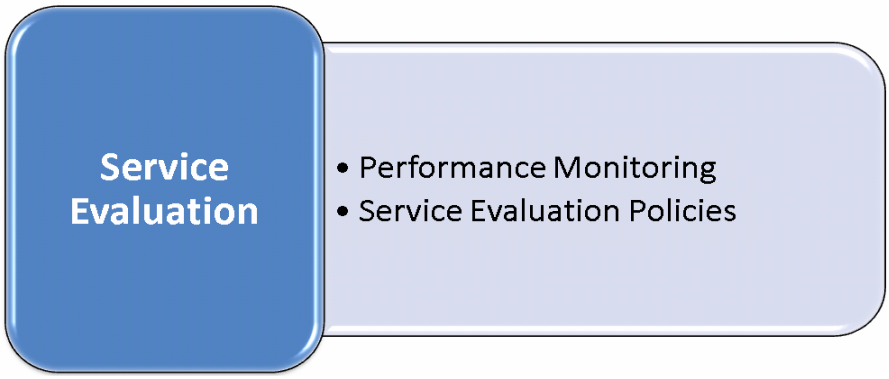
Passenger surveys, most commonly administered onboard buses, are detailed questionnaires that attempt to attain a profile of the customers who ride the bus, including demographic information, trip information, and opinions of the various characteristics of the bus system (likes/dislikes). Onboard surveys are often conducted as part of an agency's Transit Development Plan (TDP). Other passenger

surveys such as customer satisfaction and passenger environment surveys may be conducted at other times.

Automatic Passenger Counters (APC), a relatively new technology, automatically count passengers as they board and exit the bus. A capital investment for procurement and installation is necessary. There is also an operational component, as APC must be maintained and data must be transferred to a format that is usable by the agency's planners and management. In the long run, manual data collection may be more costly than APC data collection as a result of reduced labor costs. APC data may provide agencies with more data that can be made available more often. APC are also particularly useful in measuring on-time performance.

Origin/destination studies are another type of analysis to examine route performance. In these studies, passenger boarding and alighting locations are specifically identified. These checks provide the best data for identifying multi-zone passenger trips but are difficult and expensive to administer. Origin/destination studies work best when used in conjunction with APC.

Agency data, a number of performance measures require only good record keeping and can be calculated from information an agency would normally have on hand for other purposes. Examples of this kind of data include schedule data, system maps, maintenance records, operation logs, accident and incident records, financial data, fleet data, employee records, and complaint records.



Part III - Service Evaluation Methodology

The final section of this chapter examines the various ways agencies use performance data and service standards for monitoring performance and for making service planning decisions. Of specific

importance to service planners are performance measures that track the productivity and efficiencies of individual routes in the system.

III-A Performance Monitoring

A strong performance monitoring program ensures that service quality will be as high as possible. Service quality and quantity by route/service should be evaluated on a regular basis. Larger systems may evaluate their performance on a quarterly or even monthly basis, but smaller systems may find a semi-annual or annual report adequate.

In addition to full-scale service evaluation, it is common practice for agencies to track performance data on a monthly basis, especially ridership data. This will aid in the discovery of poor performing services as well as the identification of services that are performing well. The former may be candidates for service revision or elimination, while the latter may benefit from service improvements. Continuous monitoring of ridership data will provide the agency with the capability to track long-term changes in the system's performance and identify trends, which will lead to better service planning decisions.

III-B Service Evaluation Policies

In addition to performance monitoring of existing fixed route services, agencies may set up specific service evaluation policies to address substandard performance (also known as remedial analysis). This section of the report provides many examples of approaches and policies adopted by various transit agencies to evaluate service.

The Massachusetts Bay Transportation Authority's Service Policy for Surface Public Transportation (1975) outlines the procedures for addressing substandard performance. The report defines four categories of substandard performance: first time, previously substandard – improving, previously substandard – no improvement, and chronic. It is anticipated that some services will always be substandard for at least one criterion. In cases where no remedy exists that is economically, politically, or physically feasible, the substandard service will be subject to further review only on an annual basis. Of the other three categories, the top priorities for agency investigation are services that are showing no improvement followed by services that are substandard for the first time. For improving services, no further analysis will be required if the improvement is sufficient.

The report further provides specific actions that could be taken based on the area of the service that is substandard:

- For substandard performance in load factor, labor productivity, or schedule adherence, the service's schedule will be analyzed to determine possible remedies.

- For substandard performance in speed, field investigations will be conducted and discussions will be made with local traffic officials to determine measures that could be undertaken to improve speeds.

- For substandard performance in dependability, an investigation in cooperation with the Maintenance Department will be undertaken to identify the extent of the equipment and/or dispatching problem to develop possible remedies.

- For substandard performance in complaints, an investigation will be undertaken to identify the source and validity of the complaints.

- For substandard financial performance, an onboard survey will be undertaken.

Any remedial action that entails a significant change in service is usually reviewed by an Advisory Board representative from the communities affected by the change. A significant change in service is defined to include the following:

- elimination of a route
- addition or subtraction of one mile or more to a service's route length
- addition or subtraction of 25 percent or more of the average daily roundtrips in a service's schedule
- relocation or change in routing, or major portion thereof

Other reports that focus on route productivity and the approaches taken for addressing poor performance include the following:

- Lines that are performing above the passenger per hour standard, but demonstrate a trend of declining productivity or lines that are performing below the passenger per hour standard, will be analyzed to identify problem areas, and a plan to improve performance will be developed. The first step in this process will be to evaluate each service day and time period to determine compliance with the load factor standards. An assessment of route segments will also be conducted to identify specific areas of low ridership. Low ridership segments may be targeted for specific marketing efforts and/or service reductions. Any line that falls below 50 percent of the average passengers per hour for its service category will be classified as critical. A

determination will be made to continue the line, salvage portions of the existing route, or terminate service. No line shall continue in critical status for more than 6 months without the approval from the VIA board of trustees (Line Service Design Standards - VIA Metropolitan Transit 2000).

- The productivity standards are used to identify routes and services for appropriate marketing and possible revision or elimination. Separate standards are identified for each class of service. Routes are evaluated on ridership (passengers per hour or mile) or subsidy per passenger. These standards are based on the performance of the least productive 10 percent of routes in each service class for either measure or on the least 25 percent of routes in both measures. The standards for evaluating portions of routes are intended for use in identifying needed service improvements, for making modifications to specific portions of existing routes, or for identifying low productivity segments of routes (Service Standards - RTD 2002).

- Transit lines are ranked by a variety of metrics such as passengers per hour and annual subsidy. Services that fall below the 25 percentile of all routes within its category will be analyzed for the following: schedule adjustments, running time adjustments, route improvements (consolidation or through-routing), route discontinuance, or other actions such as grant funded opportunities (AC Transit Service Standards and Design Policy 2004 revised).

- Base services are not required to meet minimum ridership levels, since their operation is mandated by the network service requirements. However, YRT will still assess the base routes against ridership measures to identify good and poor performing routes and examine ways to continuously improve performance. BRT (Viva) routes are monitored as well, but are expected to perform about 50 percent higher in passengers per hour (York Region Transit – Transit Service Guidelines 2006).

- Once averages have been calculated, each route will be classified as low-performing, average, or high performing for each indicator. Low-performing routes are less than 50 percent of a system or category average. Average routes are between 50 percent and 150 percent. High-performing routes are greater than 150 percent. Low performing routes (one or two indicators) should be studied to find small adjustments that may improve timing, reliability, or access to new geographic areas, while generally preserving the format and major destinations of the route. They also could be targeted by specific marketing incentives (t-shirt giveaways, gift certificates, etc.) to raise awareness of the route. Low performing routes (three to five indicators) should be studied to find potential major adjustments, re-routings, or time changes. If the route has been low performing across 3 or more indicators for nine months or longer, TTA should strongly consider route elimination. High performing routes (one or more indicators) are at the top of

the list for passenger amenities and shelter placements (Triangle Transit Authority – Regional Bus Service Standards 2003).

- Routes within their functional classification will be evaluated annually. The evaluation will rank routes based on passengers per revenue hour and cost per trip. Each route is required to meet a minimum standard of 60 percent of the average productivity in its classification. Routes falling below 60 percent for three consecutive quarters will be placed on a Review List. (Service Evaluation & Performance Measurement Program - Madison Metro 2000).

- Passenger trips per revenue mile should be no less than 50 percent of the mean for each route classification. Passenger trips per vehicle trip should be no less than 50 percent of the mean on express routes (Valley Metro Performance Criteria and Service Standards 1999).

Several reports also had a specific procedure for trial or experimental periods for new services or changes to existing services; examples include the following:

- All new services, route extensions, or modifications will be operated for a minimum of six months. (Service Policy for Surface Public Transportation - Massachusetts Bay Transportation Authority 1975).

- New service must exceed the critical classification at the end of 180 days to be considered for continuation on a permanent basis. New service must be in compliance with its respective passenger per hour standard within 2 years from the date of implementation. (Line Service Design Standards - VIA Metropolitan Transit 2000).

- Some service changes may be implemented as experimental services which have a six-month evaluation period. During that time, the CTA board may cancel or adjust the service if it becomes apparent that it is not meeting expectations. Status reports must be provided regularly during the experimental period. (Chicago Transit Authority Service Standards 2001).

- New services should meet the applicable standards for their class of service after six months of operation. All new services will be reviewed after six months of operation and routes that have not shown adequate progress toward meeting the standards will be targeted for cost-effective actions to increase productivity or for elimination. (Service Standards – RTD 2002).

- Services introduced in new areas not previously served should be guaranteed for a minimum of 12 months of operation to ensure enough time for travel patterns to adjust and for recording of four-season ridership patterns. At the end of the 12 months, the service must meet the

minimum route performance thresholds required for its type of service. Within this trial period, interim targets are set and monitored at 3, 6, and 9 months to ensure that the new service is moving towards meeting the standard. Targets are set at 25, 50, and 75 percent, respectively. If a route misses its interim targets, the route should be re-examined to identify potential changes. Routes that introduce service in new operating periods where routes already exist, or modify an existing route are subject to a shorter 6 month trial. Interim targets are established at 2 and 4 months with levels of 33 and 66 percent. (York Region Transit – Transit Service Guidelines 2006).

Chapter Three

Consultation with Transit Agencies

During the research, Florida and national transit agencies were consulted to examine current industry practices in transit service planning with focus on three primary areas: service design standards, performance measurement, and service evaluation methodologies.

An electronic survey was created and data were collected using *Surveymonkey.com*. A link to the electronic survey was sent to all transit systems in the United States that are APTA members, plus the 14 Florida transit agencies that are not APTA members, for a total of 352 transit agencies. Responses were received from 63 agencies, for an overall response rate of approximately 18 percent. The results of the survey are compiled and analyzed in this chapter.

Table 3-1 presents the response rate for each question on the survey based on the 63 surveys completed. Questions 4, 5, 7, 8, 9, and 10 also had an "other" option; the number of respondents who chose this response is also shown below.

Table 3-1
Response Rates by Question

Question	Responses/Rate
Q1 – Contact Info	63 / 100%
Q2 – Fleet info	62 / 98%
Q3 – Department	63 / 100%
Q4 – Service design standards	62 / 98%
Q5 – Data collection methods	62 / 98%
Q6 – Performance measures for service evaluation	63 / 100%
Q7 – Frequency of performance evaluation	59 / 94%
Q8 – Methods to determine substandard routes	60 / 95%
Q9 – Methods to address substandard routes	63 / 100%
Q10 – Performance measures used to address substandard routes	62 / 98%
Q11 – Standards for monitoring new routes	48 / 76%
Q12 – Process for Implementation for new service	58 / 92%
Q13 – Other best practices	17 / 27%

Table 3-2 shows the response for the question regarding the total number of vehicles in fleet as part of question #2. Responses were grouped into categories of number of vehicles. As can be seen from the results, the survey yielded a wide cross-section of agencies based on size from the very large (>500 buses) to the very small (<19 buses).

Table 3-2
Vehicles in Fleet

Vehicle Fleet Range	Number of Agencies
4000+	1 (New York City)
500 – 1099	11
200 – 499	9
100 – 199	11
50 – 99	9
20 – 49	14
0 – 19	7

Service design standards refer to specific goals, objectives, or policies that an agency sets for itself in regards to various areas of service design. Question #4 on the survey asked respondents if they have service design standards in the categories shown in Figure 3-1. A total of 84 percent of agencies stated that they had standards for productivity measures such as passenger trips per hour and subsidy per passenger, making it the most common type of design standard. Similarly, 76 percent of agencies stated that they had standards for service delivery measures (i.e., on-time performance, shelters and amenities). Service directness ranked last, with only 35 percent of respondents indicating the use of these design standards (for such specifications as time in deviated services and timed transfers). The remainder of the categories ranged from 50 to 73 percent of respondents indicating that they had standards for those categories.

The response rate for each category may be skewed high due to interpretation of the question. For example, respondents may have checked the productivity category because they use passengers per revenue hour in their reports, but they may not have any specific service design standards for productivity measures such as “all routes must provide 15 passengers per hour.”

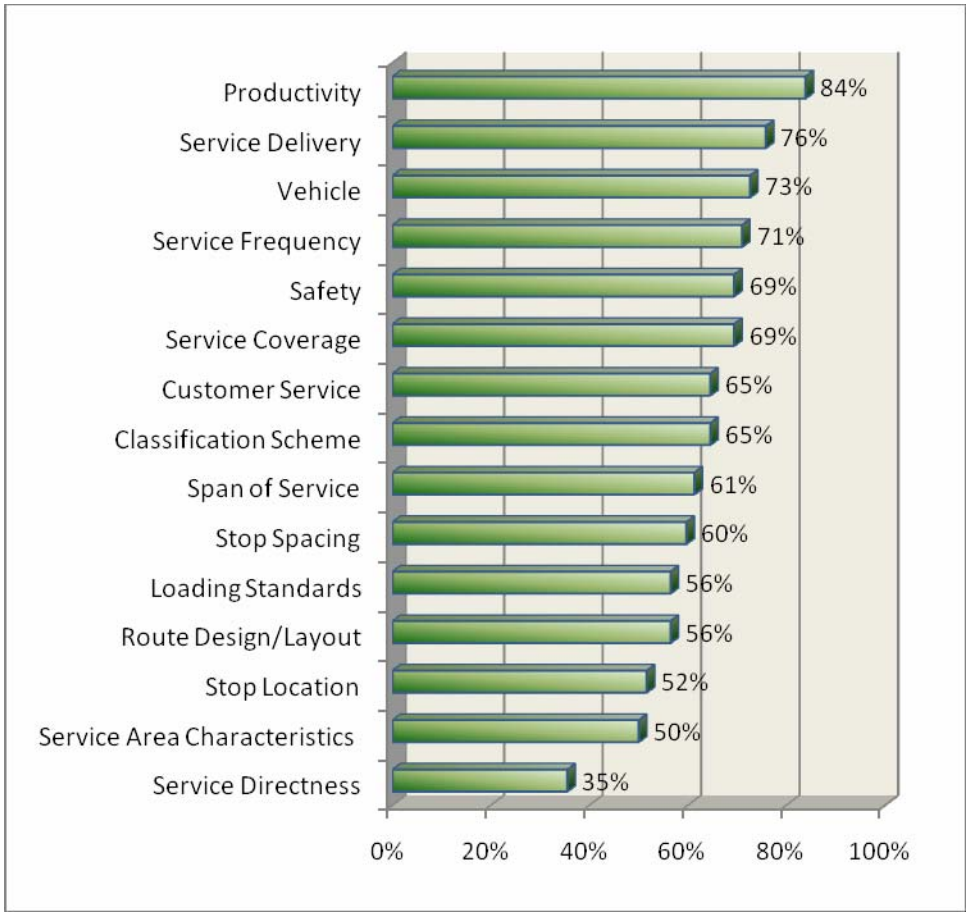


Figure 3-1
Q4. Service Design Standards

Other responses for question #4 included:

- Regional Transportation Commission in Reno, Nevada stated that their total system is designed for 80 percent productivity and 20 percent geographical coverage.
- DART in Dallas does not have adopted service standards but will be working to adopt service standards and a monitoring system in the coming year.
- Santa Barbara Metro Transit District in California has service standards for farebox recovery (*productivity*), and percentage of transfers (*service directness*).
- Regional Transportation District in Denver stated that safety and on-time performance are departmental goals.
- ASUCD Unitrans in Davis, California stated that their Short-Range Transit Plan depicts their goals, objectives, measures, and standards.
- LYNX in Orlando stated that loading standards are being developed.
- Fort Worth Transportation Authority in Texas stated that they have these standards, but in actual practice, exceptions are the rule.

Question #5 asked respondents what data collection methods they use most often to collect performance data for monitoring and evaluation. Figure 3-2 shows that 81 percent of respondents use their farebox data for monitoring and evaluation purposes. A total of 58 percent still use the low-tech approach of manual ride checks to collect data. About half of the agencies that responded use passenger surveys to collect performance data. A total of 37 percent are now using Automatic Passenger Counters (APC). Just 24 percent use Origin/Destination analyses to collect performance data.

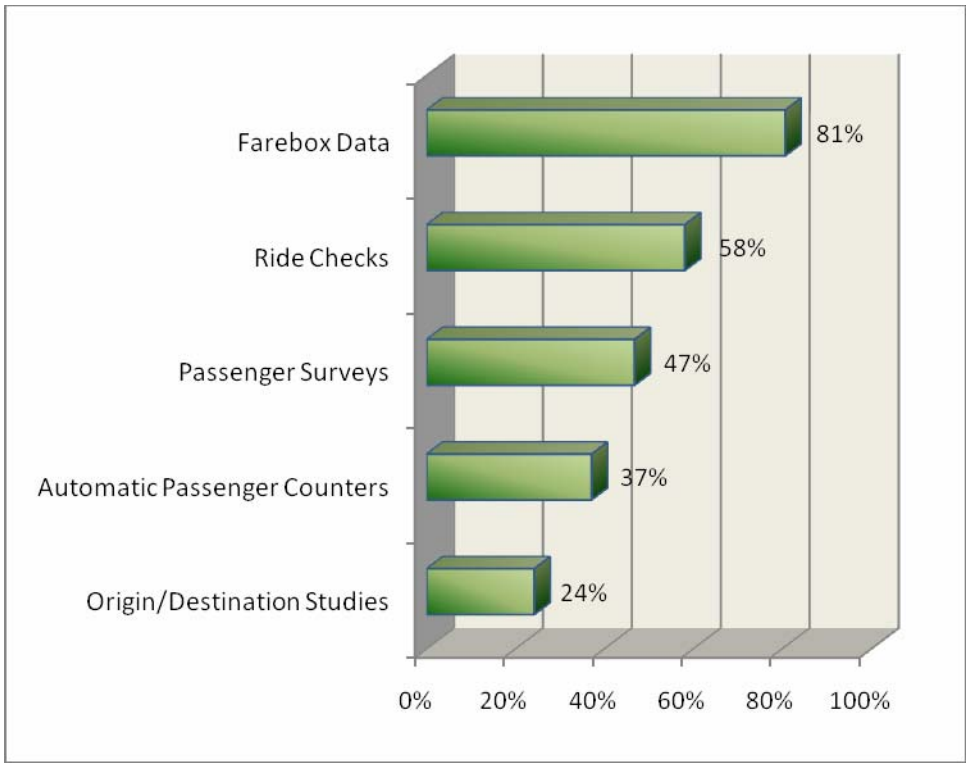


Figure 3-2
Q5. Data Collection Methods

Other responses for question #5 included:

- Orange County Transportation Authority in California stated that APC are being tested with the intent to use them eventually.
- Metro Transit in Minneapolis uses maximum load point checks (*a specialized version of ride checks*).
- Fairfield and Suisun Transit in Fairfield, California, uses remote sensing via GPS.
- Link Transit in Wenatchee, Washington, uses trip sheets (*another name for ride checks*).
- Mass Transportation Authority in Flint, Michigan, uses driver surveys.

- ASUCD Unitrans in Davis, California, has its driver's manually record boardings and departure times from bus terminals on all runs.
- Western Kentucky University in Bowling Green uses complaint/compliment calls and cards.

Question #6 asked respondents to what degree their agency uses performance measures for monitoring and service evaluation. Figure 3-3 shows that performance measures are most often used as one of many tools in making service revisions (46 percent). A total of 43 percent of agencies put a greater emphasis on measures in comparison to other methods. Only 6 percent use performance measures exclusively for service evaluation. Only 5 percent claim that performance measures are not used in service evaluation, as decisions are largely driven by other forces.

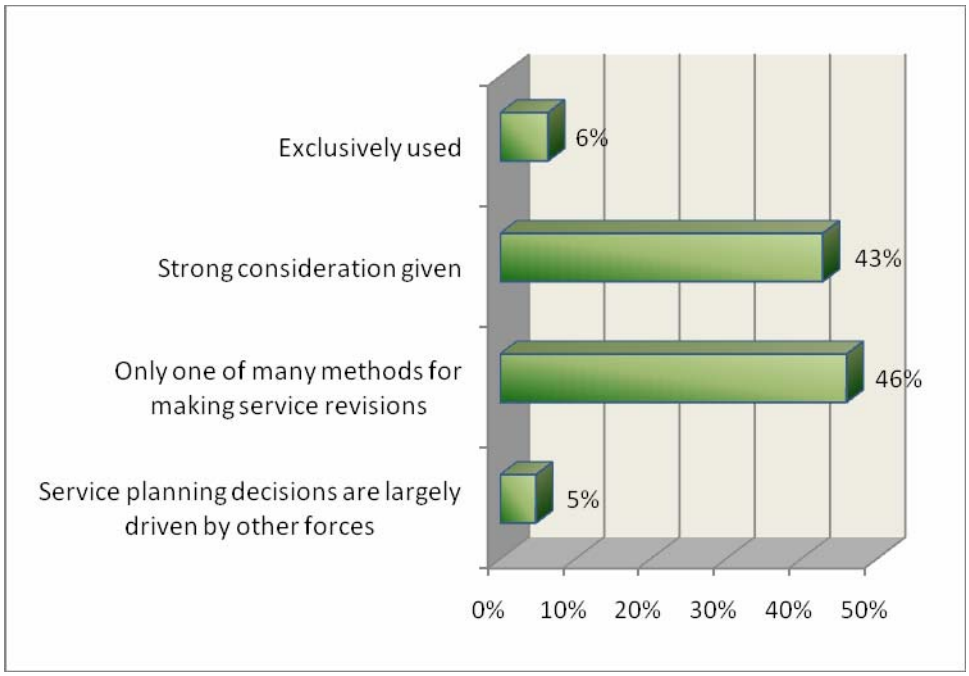


Figure 3-3
Q6. Performance Measures for Service Evaluation

Question #7 asked respondents to what degree their agency uses performance measures for monitoring and service evaluation (see Figure 3-4). The majority (53%) answered they use performance measures to monitor on a monthly basis. All other possible responses received less than a 20 percent response rate.

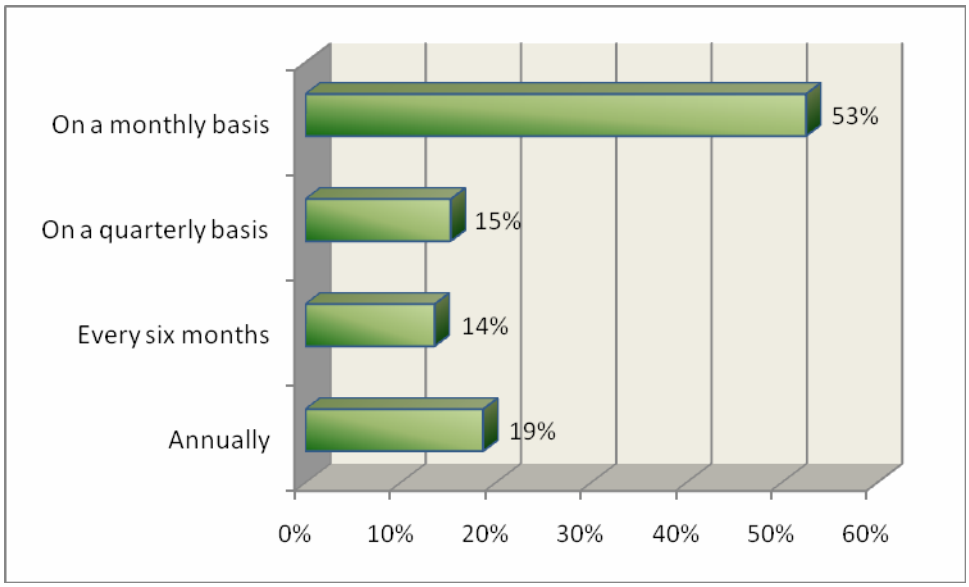


Figure 3-4
Q7. Frequency of Performance Evaluation

Other responses for question #7 included:

- Orange County Transportation Authority in California stated that ride checks are conducted on every line annually and the process is continuous. (*This is likely the case for a majority of agencies*).
- Regional Transportation District in Denver further specified that its APC data is divided into four-month increments even though their overall ridership is collected and published monthly.
- CDTA in Albany, New York, specified that there is a formal report annually, but routes are monitored on a monthly basis.
- MARTA in Atlanta and JTA in Jacksonville, Florida, evaluate their route performance three times a year.
- St. Johns County in St. Augustine, Florida, evaluates route performance only when needed as they are a very small system.
- MTA New York City Transit evaluates route performance every two years for local and limited routes and annually for express routes.

Question #8 asked what methods are most often used to determine and monitor substandard routes (routes that are poor performers). As detailed in Figure 3-5, a total of 75 percent of respondents stated that they categorize their routes into categories before analyzing performance. This enables agencies to treat certain types of service differently from others. Similarly, 62 percent use field investigations and research to determine inefficiencies on a route-level basis. A total of 28 percent used onboard surveys for the same purpose.

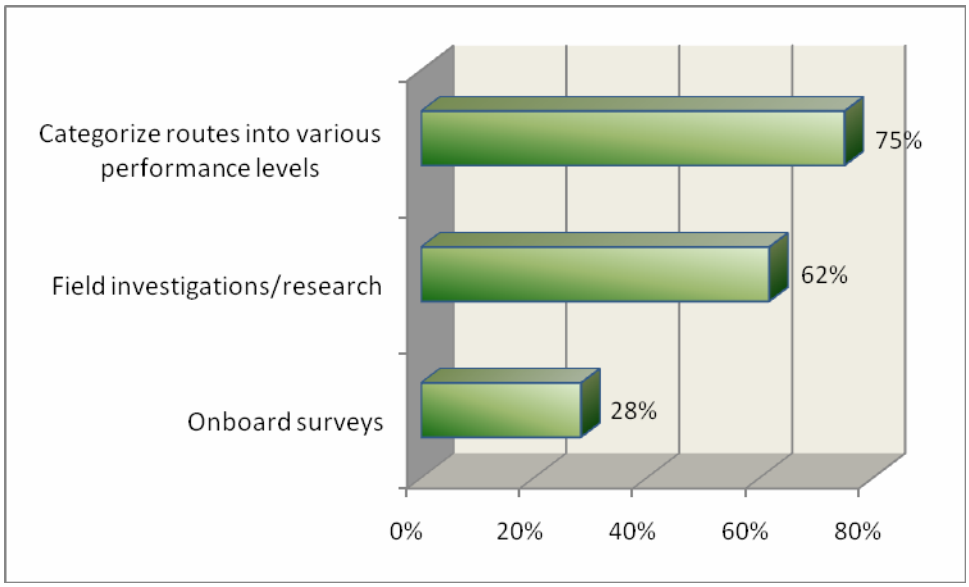


Figure 3-5
Q8. Methods to Determine Substandard Routes

Other responses for question #8 included:

- Several agencies used the word "ridership" in their answer. It is common knowledge that an agency collects ridership data to determine route performance. This question went beyond that assumption to ask about various specific methods used to separate out poor performing routes from good performing routes.
- Other agencies specified what they did after categorizing routes in various performance levels (compare individual routes with the route category performance level or compare routes to specified standards). In this regard, question #8 did not go far enough in determining these practices.

Question #9 asked respondents what methods they use most often to address substandard routes (routes that are poor performers). As detailed in Figure 3-6, a total of 86 percent said that schedules are adjusted to address poor performance. Similarly, 78 percent favored service reductions and/or realignments. About 60 percent use marketing efforts to increase awareness, while 48 percent may decide to eliminate the service altogether. Only 14 percent look for grant opportunities as a method to fund services that have substandard service.

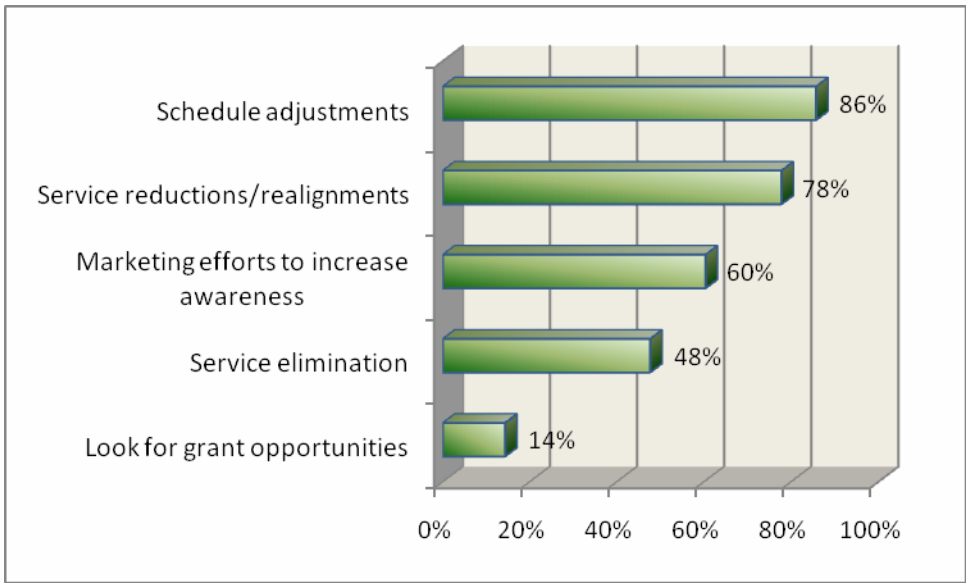


Figure 3-6
Q9. Methods to Address Substandard Routes

Other responses for question #9 included:

- The Big Blue Bus in Santa Monica, California, emphasized that there is recognition of what the City Council or vocal individual complainers will not allow to be cut.
- Orange County Transportation Authority in California, Regional Transportation District in Denver, and Citibus in Lubbock, Texas, claimed that service elimination is a last resort.
- CDTA in Albany, New York, cited that grants also include contracts with universities and employers.
- Santa Fe Trails in New Mexico said that service reductions were rare (only one instance in six years).

Question #10 asked what performance measures were used most often when dealing with substandard routes (see Figure 3-7). Passengers per revenue hour was the overwhelming choice (90%) among the three choices. Passengers per revenue mile and subsidy per passenger were both used by less than 50 percent of respondents.

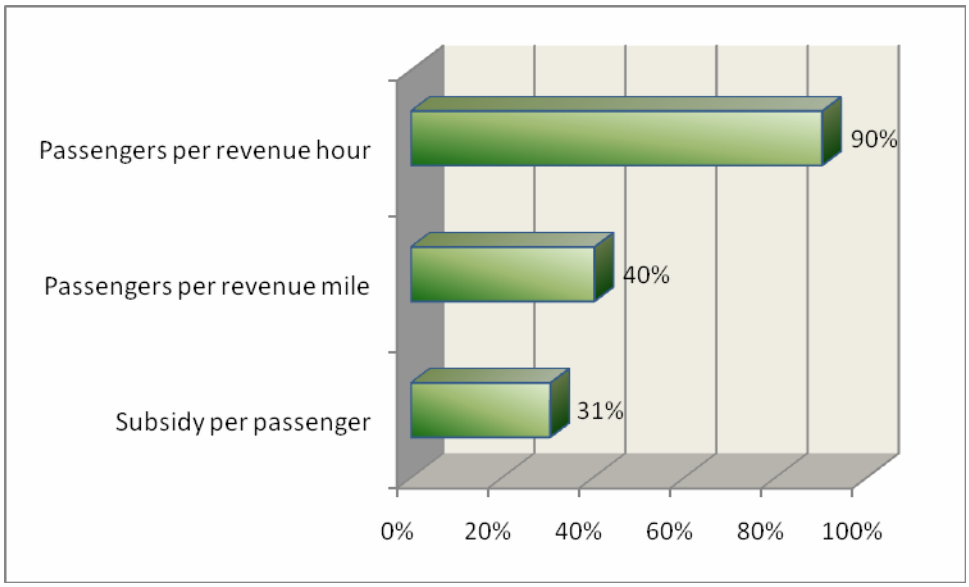


Figure 3-7
Q10. Performance Measures Used to Address Substandard Routes

Other responses for question #10 included:

- Orange County Transportation Authority in California stated that performance measures and standards are being revised and will include measures on capacity utilization and subsidy.
- Metro Transit in Minneapolis, Marta in Atlanta, and the Transit Authority of Northern Kentucky use farebox recovery rate as a measure to address substandard routes.
- RTD in Denver stated that routes must meet both passenger/hour and subsidy/passenger standards to be considered viable.
- ASUCD Transit in Davis, California, also uses the California-mandated farebox recovery ratio.
- St. Johns County in St. Augustine, Florida, also examines the cost per revenue mile.
- Citibus in Lubbock, Texas, also examines revenue per mile.
- Triangle Transit in Durham, North Carolina, looks at operating cost per passenger and cost recovery ratio.
- Fort Worth Transportation Authority in Texas stated that they look at it all, but it all boils down to cost.
- MTA New York City Transit also looks at total ridership and cost recovery.
- Santa Barbara Metro Transit District examines passengers per hour for local and shuttle services, passengers per trip for express and commuter services, and subsidy per passenger for all services unless route is a grant-funded pilot program.

Question #11 asked agencies to briefly describe any specific standards/methods your agency uses for monitoring new routes. There were some general themes that emerged from the responses. Many agencies use a trial period to evaluate new service. New service is given as little as 90 days on the low

end and a 36-month period on the high end to become productive based on agency standards. During that time, agencies typically monitor the route's performance and may make schedule/route adjustments and employ various marketing programs to boost performance.

More specific processes were noted as follows:

- Big Blue Bus in Santa Monica, California, stated that service must have less than five passengers per vehicle hour in the case of Council member supported service to be eliminated, 20 passengers per hour for services outside Council jurisdiction.
- JTA in Jacksonville stated that the farebox recovery and productivity guidelines should be applied to a new route or route extension with some caution. Any new service takes time to build its ridership base. In many cases, new services are not fully productive for several months. Therefore, new routes with productivity and performance rates greater than 45 percent of the standard for the particular service type should be considered acceptable at the end of the first year. After the first year of operation, new routes should be evaluated in the same manner as all other routes. New services should be monitored closely during the first few weeks of operation. A trial period extending approximately six months should be adequate to help determine whether or not the service change should be made permanent.
- Orange County Transportation Authority gives new bus lines one year to achieve 10 riders per hour and monitor for improvement thereafter. However, this process is currently under revision and will be changed.
- Metro Transit in Minneapolis introduces new or restructured routes as "Demonstration Routes" for a trial period of 12-18 months. Ridership performance after 12 months will be evaluated against goals. If substandard, the service may be reduced or eliminated after 18 months.
- Santa Clara Valley Transit in San Jose, California, provides new routes with a 24-month period to achieve the performance standard (passengers per revenue hour) for their route type. A graduated scale is used during the 24 months to measure expected ridership: 6 months = 70 percent of standard, 12 months = 80 percent, 18 months = 90 percent, and 24 months = 100 percent.
- Link Transit in Wenatchee, Washington, allows for services introduced in new areas not previously served to be guaranteed for a minimum 18 months of operation to ensure enough time for travel patterns to adjust and for recording of four-season ridership patterns. At the end of the 18 months, the service must meet the minimum route performance thresholds required for its type of service. Within this trial period, interim targets are set to ensure that a service that is clearly not capable of meeting the ultimate targets is identified as early as possible. Monitoring at regular intervals is completed to ensure that the new service is moving towards the appropriate standard. Targets for these interim periods are set at 25, 50, and 75 percent of

the ultimate target, respectively. If the performance at the end of each period has not reached at least 75 percent of the target value, the route should be re-examined to identify potential changes to improve its performance. If the same standard is not met in the next period, the changes should be recommended.

- Citibus in Lubbock, Texas, generally commits to providing new service for one year, no matter what the performance factors are. After one year, if the new route does not meet minimum standards and does not show any sign of building ridership to the level that will eventually result in meeting those standards, the staff will make recommendations for remediation, up to and including discontinuation of service. Links are typically considered new for two years. Goals are set for the end of maturation period, with incremental goals along the way.
- Triangle Transit in Durham, North Carolina, considers elimination for any route active for more than six months that is low-performing against the system average for three of the five indicators (*not specified*). A public meeting would be held in the jurisdiction where the change would occur.
- Fort Worth Transportation Authority does not typically use trial periods unless they have a specific subsidy or grant. Typically, it takes at least a year and usually longer for a new route to catch on and by then, regardless if it meets any established criteria, it has already developed at least a small population that is dependent upon it. If it gets off to a slow start, then it is treated as any underperforming route, trouble shooted and tweaked before elimination is considered.
- Miami-Dade Transit in Florida usually gives new routes 24 months to mature and reach minimum productivity standards. However, if after 12 months the route has failed to reach the halfway point of the minimum standards, it is reevaluated.
- HART in Tampa tries to leave a new route in operation for two years. They monitor new routes or route segments via surveys and APC data. After two years, a new route or service is expected to operate at 60 percent or higher of that services group average for passengers per revenue hour.
- Minnesota Valley Transit in Burnsville, Minnesota, provides a minimum 18-month trial period. They ignore performance for the first six months, and then look for a trend toward acceptable performance in months 7 through 18.

Question #12 asked respondents to briefly describe their process for implementation of service changes or new service. This question had the lengthiest responses (more than five pages long) because implementation of service changes is not generally a simple process. In assimilating the responses, agencies generally separated their service changes into categories of severity.

For **minor changes**, it is typical for the process to remain internal to the agency. No public comment or board approval is needed. Agencies tend to structure their minor improvements around their sign-up

periods (driver picks) or the schedules of a major university (Fall and Spring semesters). For major changes, public input, committees, and board approval all become part of the process.

Some of the larger agencies have specific guidelines for determining when a service change is considered a **major change**:

- VTA in San Jose, California, has adopted criteria to determine whether service changes are made at a staff level versus changes needed to be reviewed and adopted by the board of directors. The following service changes must be reviewed and adopted by the board, which also would include review by the board's Transit Planning and Operations Committee and a formal public meeting process: establishment or elimination of a route, a route change of more than 25 percent of route miles, a route change of more than 25 percent of route hours, or changes that might be controversial with a particular community or interested parties.
- NYCT in New York has the following policy: If the proposal will result in a change of less than 25 percent of the vehicle miles, less than 25 percent change in route mileage, and less than a one-hour change in service span, it is classified as a minor service change and sent to the NYCT president for approval and the MTA Board for information. If the proposed service change will exceed a 25 percent change in route mileage, or a 25 percent change in active service miles, or more than a one hour change in service span, a public hearing must be held.
- RPTA in Phoenix categorizes service changes into one of two categories: locally funded and regionally funded. Regionally funded service changes are tied to the Regional Transportation Plan and further defined within the Transit Lifecycle Program. Locally funded service changes are generated by local planning efforts and are tied in part to local transit plans.

The implementation of **major service planning changes** is typically structured with the following components in this order: **development of service plans, public input process, committee meetings, and approval of the city or county board**.

The **development of service plans** generally starts with a determination of need. This need could be driven by budget considerations (either cutbacks or additional funding to expand), or by requests for service from customers, elected officials, community planning boards, other governmental organizations, and, internally from employees. Some agencies develop their service plans with development of their annual budget. Transit service planners have a variety of techniques at their disposal to determine if proposed changes are warranted – Origin-Destination surveys, Geographic Information Systems (GIS) mapping of locations and land use, Automatic Passenger Counter (APC) data, Comprehensive Operations Analysis (COAs), and a technique known as sector studies (in which a portion of the service area is analyzed and recommendations are developed for improvements in route effectiveness and efficiency).

The components of the **public input process** can vary from agency to agency but basically involves some method for the public to be involved and voice concerns about any major proposed service changes. Agencies may use public hearings (the most common method), neighborhood meetings, open houses, and focus groups as ways for gathering interested customers together. Also, onboard customer surveys are another method to gauge public opinions.

Transit agencies employ **committees** as a process to refine service plans and eventually to make recommendations to the board. Committees can be internal to the transit agency and can be composed of members of service planning and operations (including bus drivers). Other transit departments may also be consulted during this process. External committees include Citizen's Advisory Committees (CACs) and Technical Advisory Committees (TACs). It may be required by the local city or county government that agencies present service changes to these committees prior to presenting to the board.

It is nearly a universal practice among all transit systems that major service changes must be **approved by the local city or county board**.

The final question on the survey, Question #13, asked the respondents if there are any other best practices in transit service planning that they use and would like to share. Following are some of the responses received:

- JTA in Jacksonville, Florida, employs an extensive, on-going public outreach program, including "Transit Talks" sessions – public meetings or open sessions at transit transfer stations, and public events. The public is invited to give comments on how to improve service or make it convenient for them to use. JTA also employs an extensive "business outreach" program. Full-time managers contact area businesses seeking cooperation in promoting public transit, or partnerships for sponsoring bus passes or services. As part of this effort, JTA conducts "transportation fairs" for employees and surveys employees for interest in transit.
- OCTA in Orange, California, is revamping its performance measures and standards and monitoring process. It will use a variety of performance measures in addition to passengers/hour and will create a line performance index which will be an input to a trend analysis comparing a line's performance to all other lines within defined service categories. Also, the agency will soon start to integrate APC data providing much greater depth and accuracy to the line evaluation process. In addition, future plans entail the use of geo-analysis using service area characteristics and origin/destination data to evaluate system performance.
- CDTA in Albany, New York, had the following suggestion regarding transit service planning: "You can never do enough public participation and outreach. Performance measures are an

important metric, but cannot be solely relied upon. In your planning, do not forget the valuable resource that is your own workforce -- some of the best ideas come from the front lines."

- MVTA in Burnsville, Minnesota, stated: "Transit service planning is not a science but an art. On-the-ground knowledge of the service territory is far more important than numerical analysis. We make extensive use of the new Census tools (On the Map, LEHD, etc.) to point toward areas of developing unmet demand."

Chapter Four
Case Studies – Best Practices in Service Planning

In Chapter Two, a broad overview examined transit service planning related research for the following three topics: Service Design Standards, Performance Measurement, and Service Evaluation Methodology. Chapter Three included the results from a survey of transit systems throughout the United States inquiring about their transit service planning practices. This chapter builds on the previous chapters by selecting a few transit service planning approaches for a more in-depth examination. The planning approaches that were chosen for this chapter were based on thoroughness, completeness, and the applicability to one of the three major service planning topics.

Case Study 1 – York Region Transit (May 2006)
Service Design and Performance Standards Focus

The York Region Transit (YRT) "Transit Service Guidelines" report was developed as part of YRT's Five-Year Service Plan. These guidelines were intended to bring clarity and consistency to the service planning process to meet varied and changing customer needs. It defined the conditions that required action when standards are not met, but allowed flexibility to respond to customer needs and community expectations in an accountable, equitable, and efficient manner.

York Region Transit

Located: York Region, Ontario, Canada

Types of Service: Bus, BRT, Demand Response

Annual Bus Passenger Trips: 18.2 million (2007)

YRT Classification System

As discussed in the transit service planning overview, many agencies categorize their fixed route services into service types for the purpose of applying varied service standards based on the service type. YRT has defined six distinct service types: Bus Rapid Transit (BRT), Base Service, Local Routes, Express Routes, Shuttles, and Community Bus Services.

YRT's **BRT system,** named Viva, is designed to provide frequent, limited stop service using distinct vehicles, ITS, off-board payment, and queue-jump lanes.

YRT's **base service** consists of certain routes that are designated as such to ensure a basic level of access throughout the service area. Base services operate seven days per week in all operating periods. Base services are designated to serve main arterial roads and corridors to ensure 90 percent of all major residential and employment areas are within 1,000 meters of transit service.

Local routes serve as feeders or neighborhood circulators. They operate within the various communities connecting those communities to the major local activity centers or corridors and to the grid network for transfers between routes. Local routes operate primarily on minor arterial roads to serve local destinations. Local routes are not recommended to operate on minor local roads unless required for operational needs or to serve major passenger destinations.

Express routes carry significant numbers of passengers between two distinct points. They are used when ridership warrants service in a particular corridor and are "overlaid" on top of existing service. They should be designed to ensure that 75 percent of the passengers within the corridor can take advantage of the express service and that it can save at least 15 percent of the regular route travel time. Limited stops may be used to meet the passenger access requirements. Express route service is determined by vehicle loading and route performance standards.

Shuttles provide local service to train stations, Viva stations, and other major destinations. They are designed with consideration for the specific schedules of these other modes and employment shifts. Shuttle routings are designed to be short and as direct as possible to maximize customer convenience. Shuttle route frequency is determined based on train and employment schedules.

Community bus services are fully-accessible transit services designed for seniors and people with disabilities who can use conventional fixed route transit. They are specifically routed to provide better access to senior's residences, medical facilities, community centers, and shopping areas.

YRT Service Standards

YRT's Service Standards are used for evaluating transit routes and are the basis for making decisions concerning the introduction of new services. The following standards are defined in the YRT Transit Service Guidelines: route coverage, maximum walking distance, service levels, span of service, vehicle loading, route performance by service type, establishing new service, route directness, and location of bus stops.

Route Coverage – YRT will consider new or revised routes to serve residents, employment, schools, major shopping centers, and public facilities in the urban area that are beyond the maximum walking distance.

The **Maximum Walking Distance** to a stop should be 500 meters (1,640 feet) during weekday and Saturday daytime service. It should be 1,000 meters (3,280 feet) during evenings and Sundays/Holidays.

Minimum Service Frequencies and Span of Service are defined as shown in Table 4-1.

Table 4-1
YRT Service Span and Frequency Guidelines

Service Span	Service Frequency			
	VIVA Routes	Base	Local	Community Bus
Weekdays				
6:00 to 9:00 a.m. / 3:00 to 7:00 p.m.	15	20	30	60
9:00 to 3:00 p.m. / 7:00 to 11:00 p.m.	15	30	60	120
Saturdays				
6:00 a.m. to 11:00 p.m.	15	30	60	120
Sundays/Holidays				
9:00 a.m. to 11:00 p.m.	15	60	60	120

Vehicle Loading – YRT will design its services to keep the number of passengers on its vehicles at a comfortable level and always within the limits of safety. In peak periods, this means that some passengers will be expected to stand for part of the trip. In off-peak periods or when service is operated on a highway, a seat should be provided for all customers. Consideration is given to matching the capacity of the vehicles to the ridership levels on the route to avoid unnecessary increases in service levels. Passenger standards are calculated on the basis of an average over one hour in the peak period, at the busiest point on the route. Table 4-2 shows the average maximum vehicle load for each type of service.

Table 4-2
Vehicle Loading Standards

Service Type	Average Maximum Vehicle Load (passenger per vehicle)
BASE, LOCAL and EXPRESS routes	
60-foot Bus (Viva BRT)	72
40-foot Bus	55
35-foot Bus or 40-ft Bus (Viva BRT)	48
30 foot Bus	40
EXPRESS Route (High-speed or highway)	100% of seating capacity
SHUTTLE	100% of seating capacity
COMMUNITY BUS	
Peak	100% of seating capacity – max 60 minutes
Off-Peak	100% of seating capacity – over 60 min period

Route Performance – YRT must meet overall performance objectives as well as minimum performance levels established for each route type. Base services are not required to meet minimum ridership levels. However, YRT always assesses the Base Routes against the ridership measures to identify good and poor performing routes and examine ways to improve performance. Viva routes are generally expected to perform about 50 percent higher in boardings per hour than base routes. Route performance service standards for the remainder of service types are shown in Table 4-3.

Table 4-3
Route Performance Targets (Passenger Boardings per Hour)

Service Type	Weekday Peak		All Other Times	
	Average	Minimum	Average	Minimum
BASE and LOCAL Routes	30	10	22	7
EXPRESS ROUTES				
Fixed Route	30	10	30	10
Business	35	30	35	30
SHUTTLE	25	20	25	20
COMMUNITY BUS				
Fixed Route	15	5	12	4
Demand Response	10	5	8	3

Establishing New Transit Service – Service needs (i.e., investigating whether a route should be provided or not) for Base or local routes, express routes, and shuttles are determined by performance levels. A community bus service has an additional threshold to be considered – a service area population of 15,000 or greater.

Services introduced into new areas not previously served should be guaranteed a minimum of 12 months of operation to ensure enough time for travel patterns to adjust and for recording of four-season ridership patterns. At the end of 12 months, the route must meet the minimum route performance thresholds required for that type of service.

Within this trial period, interim targets are set to ensure that a service is on track to meet the requirements by the end of the period. Monitoring at three, six, and nine months is completed with targets being 25, 50, and 75 percent of the ultimate target, respectively. If the performance at the intervals has not reached at least 75 percent of the target value, the route should be re-examined to

identify potential changes. If the same standard is not met in the next period, the changes should be recommended.

Modifications to an existing route or span of service extensions are subject to a similar evaluation, but over a shorter time period of six months. Interim targets are established at two and four months, with target levels at 33 and 66 percent of the ultimate target.

Route Direction is a measure of how much a route deviates from the most direct path between the start and end points of the route. It is measured by a ratio. A ratio of 1.0 signifies no deviated segments. The higher the directness ratio is the greater the length of the deviations. Each service type has a range for this standard as shown in Table 4-4.

Table 4-4
Route Directness Ratio

Service Type	Ratio
BASE and Viva	1.0 to 1.1
LOCAL	1.0 to 1.2
EXPRESS – Fixed Route	Equal to or less than the underlying route. 1.0 within the express or limited stop portion of the route.
EXPRESS – Business	1.0 outside of any local service area. Local service areas should be limited to 5 stops or less.
SHUTTLE	1.25 to 1.75
COMMUNITY BUS	Less than 2.5, Less than 2.0 for Local Routes in small communities

When planning for new route deviations, the deviation must attract enough new passengers to the route to make the change worthwhile. If the deviation can be achieved with existing resources, the new ridership gained should be no less than 25 percent of the passengers affected by the deviation.

Bus Stop Standards include stop spacing, stop location, and shelter and amenities placement. The spacing of stops should not normally be less than 250 meters (820 feet) in developed areas and 500 meters (1,640 feet) in undeveloped areas.

Bus stops at intersections should be located in the safest position, considering traffic and street conditions. Where possible, stops should be located close to signalized intersections. At Viva transfer points, YRT stops on the intersecting routes should be located at the near side of the intersection wherever possible to facilitate transfers.

Bus bays should be considered for stops located near major trip generators, transfer points, timing points, or anywhere else where a bus is likely to have an extended stop time. Priority factors in selecting bus stops as candidates for shelters include:

- all terminals and transfer points
- high boarding locations (more than 35 passengers in peak periods)
- unique exposure to inclement weather
- in front of senior residences and other institutional facilities

Case Study 2 – Palm Tran Service Guidelines (1999)
Performance Monitoring Focus

The 1999 Palm Tran Service Planning Guidelines were established to provide a means for Palm Tran to balance the opposing demands of quality of service versus cost effectiveness. Part of the guidelines includes a process to evaluate and monitor route performance.

This process uses passenger trips per revenue hour as it is a very strong indicator of the effectiveness of service consumption. Revenue hours are used in this ratio since they are a sound representation of the resources consumed in providing service. All fixed routes are ranked in a table and compared to the system average. A second table goes further by comparing and ranking the weekday performance of routes within their "type of service" category (e.g., trunk, cross-town, and circulator).

Palm Tran

Located: **Palm Beach County, Florida**

Types of Service: **Fixed Route, Paratransit**

Fixed Route Annual Passenger Trips: **10.1 million**

Fixed Route Buses: **150**

Annual Operating Expenses: **$69.1 million** **(all modes)**

Source: 2007 NTD

These tables permit for the comparison of routes with similar operating characteristics.

The route evaluation process is useful for two purposes - first, to highlight those routes that are declining in performance over time, and second, to highlight the routes that continually rank in the lower quartile. These routes can then be singled out for more detailed analyses including ridechecks, on-board surveys, and/or increased marketing efforts to aid in increasing the route's performance or in uncovering the need for specific changes.

When establishing guidelines for route performance, two methods of evaluation are possible. First, the measures used can have an absolute predetermined standard (e.g., routes must perform at a value greater than 20 passengers per revenue hour). Second, measures can be relative, whereby the route's performance is compared against the performance of other routes (e.g., routes must be within 50 percent of the system average). The following steps may be considered if a route consistently falls within the lowest quartile of the system network:

- Targeted marketing and/or special promotions
- Route realignment (to eliminate non-productive route segments, reduce route mileage and/or increase speed, or ensure that major activity centers are served)
- Rescheduling
- Frequency changes (or the implementation of short-turn trips, which will reduce frequency on outlying route segments with lower ridership)
- Service span or service day adjustments

If these remedial actions do not result in improved route performance at the end of a 12-month period, the service should be considered for elimination or modification of service type.

Case Study 3 – Southeastern Pennsylvania Transit Authority (September 2004 Revision) Service Evaluation Methodology Focus

Southeastern Pennsylvania Transit Authority (SEPTA) Service Standards and Process (revised 2004), provides a detailed process for evaluating new service proposals. This process provides an objective and systematic procedure to compare service proposals with respect to passenger and community benefits relative to the cost of providing the services. This evaluation consists of four parts: 1) cost analysis, 2) ridership and revenue forecast, 3) operating ratio and analysis, and 4) community benefit analysis.

SEPTA

Located: **Philadelphia, Pennsylvania**

Types of Service: **Bus, Heavy Rail, Commuter Rail, Light Rail, Demand Response, Trolley**

Annual Bus Passenger Trips: **170.5 million**

Fixed Route Buses: **1,363**

Annual Operating Expenses: **$916.4 million**

Source: 2007 NTD

Cost Analysis

The operating cost of each proposal is computed utilizing unit costs for operating miles, hours, and peak vehicles. The number of hours and miles are computed after conducting a field examination of the proposal's service area. Mileage is calculated using odometer readings, verified with a planimeter or mapping software; running time is computed by simulating transit operating speeds and comparing the times to similar route segments.

Required service levels are determined and draft schedules are prepared. The peak vehicle requirement is determined. Unit costs are then applied to both components to calculate the total cost of the proposed change. Unit costs are updated at the close of each fiscal year.

Ridership and Revenue Forecast

Ridership is forecasted using recently-available census data, levels of employment along segments under consideration, population and employment forecasts, and observed travel patterns on similar services serving comparable markets. Revenue is then calculated by multiplying the forecasted ridership by the average fare of the specific operating district.

Operating Ratio and Analysis

Annual passenger revenue is divided by the annual cost to determine a route's operating ratio. Proposals must meet the minimum acceptable operating ratio, presently, 60 percent of the suburban transit average operating ratio.

Community Benefit Analysis

Recognizing that the annual net change in cost, revenue, ridership, and operating ratio are not the only measures of a service's value, additional criteria are used to determine the net benefit of particular services to the community. The effect of changes to accessibility, changes to travel time, and the potential elimination of the need to transfer is considered.

In this analysis, various beneficial elements are assigned benefit points according to the relative importance to the community. Additional passengers gained from the new service gain points, while passengers lost lose points. Eliminating transfers, improving travel time, and decreasing walking distance are all elements that gain benefit points. Additional transfers, added travel time, and increased walking distance lose benefit points. Total benefit points are divided by the proposal's cost to determine a Final Benefit Score.

For the purpose of comparing a proposed change on an existing route, a Final Benefit Score is computed for the existing route as it is presently operated and compared with the Final Benefit Score of the proposed change. If the proposal has a higher score than the existing route, the proposal would be considered as part of the Annual Service Plan. If not, it would not be recommended for approval. For a completely new route, a Final Benefit Score would be computed for the purpose of comparison to other proposals.

Annual Service Plan

All proposals are then included in the Annual Service Plan. This plan is a one-year plan that identifies new transit services or significant changes to existing services for the following fiscal year. The plan

identifies incremental changes that are designed to achieve specific service goals and objectives and opportunities for cost-effective service expansion. Each Annual Service Plan is developed concurrent with the annual Operating Budget, as it is prepared at the same time each year and follows a defined process allowing for municipal, governmental and public input.

All major route and service adjustments that impact SEPTA's operating budget will be planned and implemented according to the Annual Service Plan. This includes route suggestions that originate from both within and outside of SEPTA. As part of the plan each year, routes that have failed to meet the minimum operating ratio standard will be candidates for targeted marketing, schedule adjustments, realignment, consolidation, or discontinuance. Expenses saved as a result of these adjustments will be budgeted toward improvements.

Case Study 4 – Chicago Transit Authority (2001)
Service Evaluation Methodology Focus

The Chicago Transit Authority (CTA) has a structured process for evaluating services and proposed changes that is tied to the annual budget, yet is responsive to small market changes throughout the year. Request for service changes and new services can be proposed by anyone – private citizens, elected officials, CTA employees, employers, etc. They can also be the result of ongoing monitoring and data collection.

The Bus and Rail Service Committees have an advisory role for service changes. These are internal committees that meet monthly or as needed to:

- identify issues and opportunities
- ensure the proposed service changes can be operated reliably and safely
- identify the actions that may be needed to implement changes

Chicago Transit Authority

Located: Chicago, Illinois

Types of Service: Bus, Heavy Rail

Annual Bus Passenger Trips: 309.3 million

Fixed Route Buses: 2,222

Annual Operating Expenses: $1.4 billion

Source: 2007 NTD

All proposals must be reviewed and analyzed by CTA Planning and Development staff. To efficiently screen, analyze, and evaluate the merits of service change proposals, the Service Change Committee was established within Planning and Development.

The process for evaluating and implementing service change proposals is dependent upon the magnitude of the change, which is determined by the Service Change Committee. Table 4-5 shows various service change types.

Table 4-5
CTA Service Change Types

Type	Definition	Examples
Minor	Routine small changes to better align services with demand	• Running time adjustments • Departure time adjustments • Span of service changes of ½ hour or less • Bus reroutes due to detours • Service internal or Train length changes to match service levels with ridership • Changes to bus stop locations
Moderate	Small changes to routes or service configurations with limited impact and modest costs	• Bus reroutes of less than 1 mile • Route extensions of 1 mile or less • Service changes to reflect changes in street patterns
Major	Changes that will have significant impacts on customers and resources	• Route changes that affect more than 25% of a route's passenger miles or vehicle miles • Changes requiring new facilities and/or capital expenditures at a cost level that requires board approval.

Minor or moderate changes such as running time adjustments, bus detours due to construction, bus stop location changes, and bus reroutes/extensions of less than one mile are evaluated by the Service Change Committee and can be implemented throughout the year. These are changes that have little or no impact on the budget or vehicle allocation.

Major service changes that will have a significant impact on customers or resources must undergo a Semi-annual Review and may be implemented only twice a year. These changes do impact the budget and vehicle requirements and must be approved by the Board before they can be implemented. Service analyses will be conducted using a consistent set of evaluation criteria (as shown in Table 4-6), based on whether the change is a service improvement or a service reduction.

Table 4-6
CTA Service Evaluation Criteria

Service Improvement	Service Reduction
Primary • Net cost per new passenger • Available budget • The rationale for the change • Existing and projected ridership • The number of new passengers • Existing and projected operating costs • Existing and projected fare revenue • Implications to service coverage	Primary • Net savings per passenger lost • The rationale for the change • Existing and projected ridership • Existing operating costs • Existing fare revenue • Implications to service coverage
Secondary • Market change, past, present, and projected • Change in travel time for existing passengers • Key characteristics and demographics • Contribution to policy objectives • Other factors as appropriate	Secondary • Market change, past, present, and projected • Change in travel time for existing passengers • Key characteristics and demographics • Contribution to policy objectives • Impact on accessibility • Other factors as appropriate

The semi-annual review ranks major qualified service changes accumulated during a six-month period. This ranking determines CTA's best investment, and is used as a starting point in decision-making for the following year's budget preparation.

The Board is provided with the recommended service changes and a list of all proposals with their relative rankings. These are compared to the system average performance. Additionally, the Board receives a description of the change, its justification, and cost and ridership implications in order to better make a decision.

Case Study 5 – VIA Metropolitan Transit (2000)
Service Evaluation Methodology Focus

VIA Metropolitan Transit

Located: San Antonio, Texas

Types of Service: Bus, Demand Response, Vanpool

Annual Bus Passenger Trips: 40.6 million

Fixed Route Buses: 450

Annual Operating Expenses: $129.2 million

Source: 2007 NTD

VIA Metropolitan Transit's Service Line Standards (2000) outlines four different processes: one for new service, one for major service revision, one for minor service revision, and one for internal adjustments.

Any new service and major service revisions have basically the same process. This involves the Customer Service Department conducting a meeting to discuss the proposed new service or major revision. A Service Revision Form will be completed and forwarded to Finance to calculate the cost associated with the new service. Comments from all Department Directors will then be solicited by Customer Service. The completed Service Revision Form will be sent to the General Manager and Assistant General Manager for approval. The Customer Service Department also presents the resolution with budget considerations to the VIA Board of Trustees for their approval.

Minor service revisions include new turnbacks, route extensions, or route changes that affect less than 25 percent of a line's route miles or major schedule changes. The process for minor service revisions is the same, except approval from the Board of Trustees is not required. A staff report will be made by the General Manager to the Board of Trustees on any service revisions that are deemed to be of significant interest.

Internal adjustments include minor schedule or route changes that require immediate attention to correct operating problems or changes that do not have a negative effect to the overall operation. Examples of this type of change are minor changes in runtimes, trip times, or headways, the addition of extra trips to resolve overload problems, or changes to deadhead routes. These types of adjustments may be made by the authority of the Director of the Customer Service Department.

Chapter Five
Transit Service Planning – Model Approach

Introduction

Building on the previous chapters, Chapter Five takes the lessons learned and applies them to a model approach for a transit system to use as a guide for service planning in the three main areas – service standards, performance measures, and service evaluation methodology. This chapter explains the purpose of a systematic approach to service planning and defines the key components that should be part of any service planning program.

Why Service Planning?

Service planning is extremely important for a transit system so that it can supply enough service to meet the demand of its customers in the most cost effective and efficient way. Without service planning, there would be no guidance as to where to provide service, when to provide service, and how much service to provide. The agency also would not know the needs of its customers or the impact on its infrastructure (vehicles and amenities). Without adequate performance measures and a service evaluation methodology, an agency will not have any point of reference to make internal comparisons over time or versus peers, to identify necessary changes needed to provide more effective and efficient service or service. In Florida specifically, with rapid population growth and changing demographics, the transit system must constantly reassess the potential for new and different services on an ongoing basis.

A transit system has a choice to employ good service planning techniques and methods (a proactive method) or to operate in mode that is simply reactive to external circumstances. As responses to question #6 on the survey showed, most agencies make service planning changes based on performance measurement only part of the time and are forced to yield to external circumstances at other times. Unfortunately, transit service planning is not an exact science and, therefore, the best that can be done is to provide a best practices guide and attempt to apply those practices to the agency as fully as possible. If service changes are made solely due to external circumstances such as customer requests or complaints, lack of funding, or the current political support of the area for transit, then the system will soon grow either inefficient or will not adequately meet the needs of its customers.

Why a Systematic Approach?

Transit service planning lends itself to a systematic approach, as almost every aspect of transit service can be measured and standardized. Many agencies (especially outside of Florida) have very aggressive standards and service evaluation methodologies to guide the development of their transit service. It is the purpose of this chapter to develop a modeling framework for a system to use to develop new service planning standards and methodology or reshape their current practices.

Service Standards

Key Components

The key components of service standards are explained and many examples of such standards are provided in Chapter 2. These components are:

A. Classification System or Service Types
B. Service Availability (where do you put service?)
C. Travel Time and Capacity (when to put service and how much?)
D. Service Delivery (Impact on customers)
E. Vehicle Standards (impact on fleet)
F. Other Considerations – Service Equity

A. Classification System or Service Types

A transit system must define how it wants to categorize its services before it defines other standards. This is because some service availability, travel time and capacity, and some service delivery measures are affected by service type. There are many different ways to categorize routes, and an agency will want to categorize them based on what makes the most sense for their particular agency. The size of the agency is a major consideration. A large system (200+ vehicles) will likely use multiple types of service, while a very small system (<10 vehicles) might only have one type or two types. Table 5-1 shows the various service types that an agency may use and how they relate to other standard components.

Table 5-1
Service Types to Form a Classification System

Functional Classifications		**Service Availability**	**Travel Time and Capacity**	**Service Delivery**
Very Small System (<10 vehicles)	*Medium/Large System (10-200 vehicles)*	**B**	**C**	**D**
Function of the population served				
Commuter/work-based service	Commuter/work-based service	Primary	Secondary	
Community Service	Community Service	Primary	Secondary	
	Student/University	Primary	Secondary	
	Special Events	Primary	Secondary	
Function of route design				
Unlikely	Radial Routes	Primary	Secondary	
	Crosstown Routes	Primary	Secondary	
	Circulators	Primary	Secondary	
	Feeders/Shuttles	Primary	Secondary	
	Regional Service	Primary	Secondary	
Function of number of stops/service frequency				
local service	local service	Secondary	Primary	
	limited stop service/Express service	Secondary	Primary	
	Flexible service/route deviation	Secondary	Primary	
	Low Density service	Secondary	Primary	
	BRT - Larger Systems (100+ veh)	Secondary	Primary	
Function of time of day				
Day	Peak Period	Secondary	Primary	Primary
Saturday	Non-Peak	Secondary	Primary	Primary
Other functions unlikely	Night	Secondary	Primary	
	Saturday	Secondary	Primary	
	Sunday	Secondary	Primary	

For systems that fall somewhere in the middle of that range, generally, it is a best practice to define a core or base set of routes and label them as ***local service*** or other such name. These routes will comprise the majority of the system's routes and will most likely have service frequencies that range from 30 to 60 minutes in length. They typically operate on arterial streets. ***Limited stop service or express service*** is generally an option for areas with larger populations and/or dense areas of employment. ***Low density service*** or ***lifeline service*** provides a low level of service to areas with low population density and operate on secondary streets. These types of routes typically operate with 60-minute headways or higher and will be the least effective and efficient routes in the system. It is a best practice to limit this type of service to what can be accepted by the public. A better option for areas with low density are community-based services or route deviation services, which may consume fewer revenue hours of service and therefore be less costly to operate providing better farebox recovery and efficiency. Still, low density fixed route service is a better option than even more costly demand response service.

Another way to classify services is by a function of route design. The most common classifications for route design are radial or trunk, cross-town, circulator, and feeder/shuttles. These classifications are best used in conjunction with transit modeling tools.

Another major consideration when deciding standards is time of day. Typically, agencies should have different standards based on peak traffic times (morning and afternoon) versus non-peak traffic times (midday and evening) versus night. Usually Saturdays and Sundays are separated out since service volumes vary considerably on the weekends versus the weekdays.

Other types of service such as student-based transit, feeders to rail, special event service, and regional service are special cases that will not apply to all agencies and therefore must be addressed on a case-by-case basis.

B. **Service Availability (where do you put service?)**

After an agency has decided on a classification scheme, standards on the availability of service can be defined. Typically, these standards will be used to determine where new service may be the most beneficial, but also could identify areas that are currently over-served due to the demographics of the area. ***Service area characteristics*** such as population and employment density are two major factors, but household income, age, and vehicle availability of the population all can be indicators of where service will yield the highest ridership results. Service area characteristics relate directly to the type of service provided and the frequency of service. A best practice is to perform a transit needs or propensity analysis identifying these areas based on the agreed upon criteria. This criterion may vary

based on the unique nature of each system's geography and demographics. Only 50 percent of agencies surveyed stated that they use service area characteristics to determine the location of service.

C. Travel Time and Capacity	Relates to	Measures	Best Practices
• Service Frequency	• Service Area Characteristics • Route Layout and Design • Passenger Loading • On-time performance • Service Equity	• None	• Service Frequencies by service type • Clockface Headways • Demand-based headways for University settings/BRT

Figure 5-1 Service Area Characteristics

Other considerations for location of service on a smaller level (individual routes and stops) include service coverage, route layout and design, and stop location and spacing. ***Service coverage standards*** typically warrant that a certain percentage of the population is within ¼ or ½ mile of transit stops. When a service planner makes specific routing or stop location decisions, consideration should be given to the streets or locations that serve the most people and therefore are able to meet the standard. Automatic Passenger Counters (APC) can be very useful in this regard to determine routing and stop locations that have the highest ridership. Service coverage relates to type of service and frequency, but has an inverse relationship with service directness. The more direct a service, the less area it can cover.

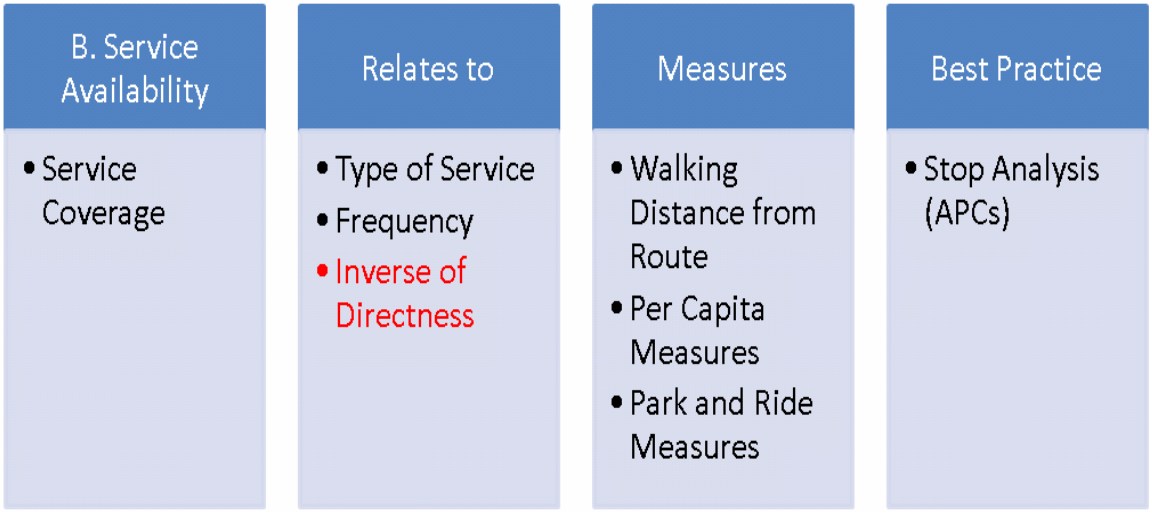


Figure 5-2 Service Coverage

Route layout and design standards are generally less common and not as critical as other service availability standards. Typically, they define route spacing or serve to reduce duplicative service. This may be applicable for very large systems that may want to space out services, but for the typical size of systems, these standards have limited applicability and/or are under the best discretion of the service planner. Another type of standard that fits in this category is roadway conditions/safety. Once again, the discretion of the service planning department can be relied upon in conjunction with the local Department of Transportation District Office to make sure that service is operating on safe roadway conditions without the requirement of a standard.

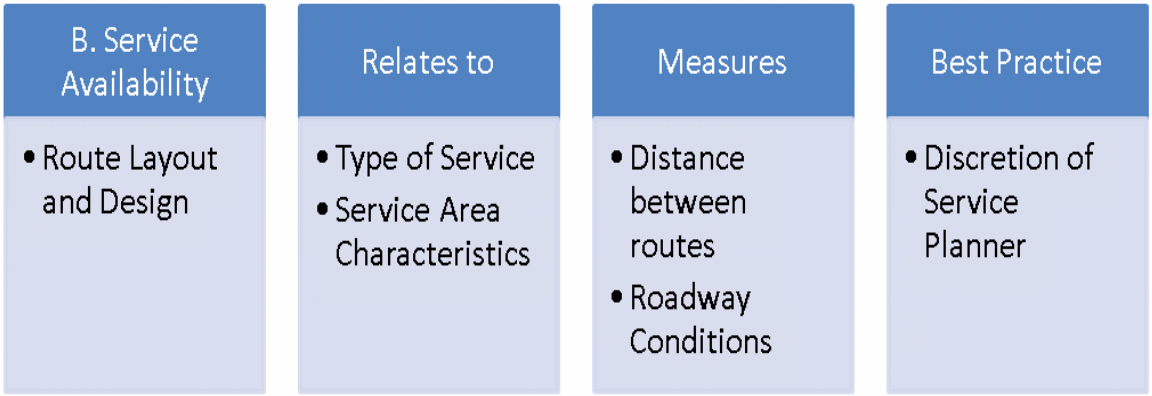


Figure 5-3 Route Layout and Design

Stop location and spacing standards will be at the discretion of the transit service planner as no industry-wide consensus or best practice exists. Some agencies prefer far-side stops, and others prefer near-side stops. Stop location will most likely occur on a case-by-case basis and be extremely dependent upon the local geography (where can the stop be safely placed?) Bus bays and turnouts are another consideration and should be placed in areas located near major trip generators, transfer points, or anywhere a bus is likely to have an extended stop or layover time. Bus stop spacing standards typically vary based on the density of the area with most systems using urban core, suburban, and rural as the defining terms.

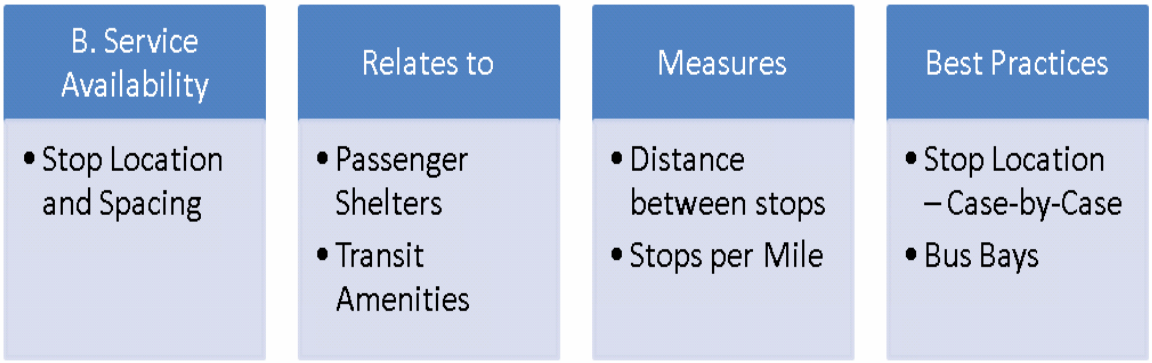


Figure 5-4 Stop Location and Spacing

C. Travel Time and Capacity (when to put service and how much?)

The amount of service that an agency decides to provide on a system level is a fundamental decision and one that should be aligned with the agency's mission and goals. Service frequency is one of the most fundamental components of transit as it relates to and affects almost all other aspects of the system. A system may decide to provide service completely based on demand or may set some policy guidelines to be followed. Policy guidelines typically involve setting specific minimum ***service frequencies*** (or headways) by service type. For example, a core route in the system may be required to have a 30-minute headway during peak hours, while a low-density route may only be required to have a 60-minute headway regardless of the time of day. Night, Saturday, and Sunday service may also have higher headways due to policy. Demand based headways are typically used for services that operate on a headway of less than 15 minutes for services such as Bus Rapid Transit and some routes in transit-heavy university settings. Another aspect of service frequency that is widely practiced by transit systems and considered a best practice is clock-face headways. Basing your schedule on intervals that divide evenly into 60 (10, 12, 15, 20, 30, 60) helps passengers to better predict arrival times at stops than having varying intervals each hour. It also eliminates the need for complex schedules. Some efficiency is sacrificed, but it is widely accepted by the industry that the attractiveness for riders outweighs any loss of efficiency.

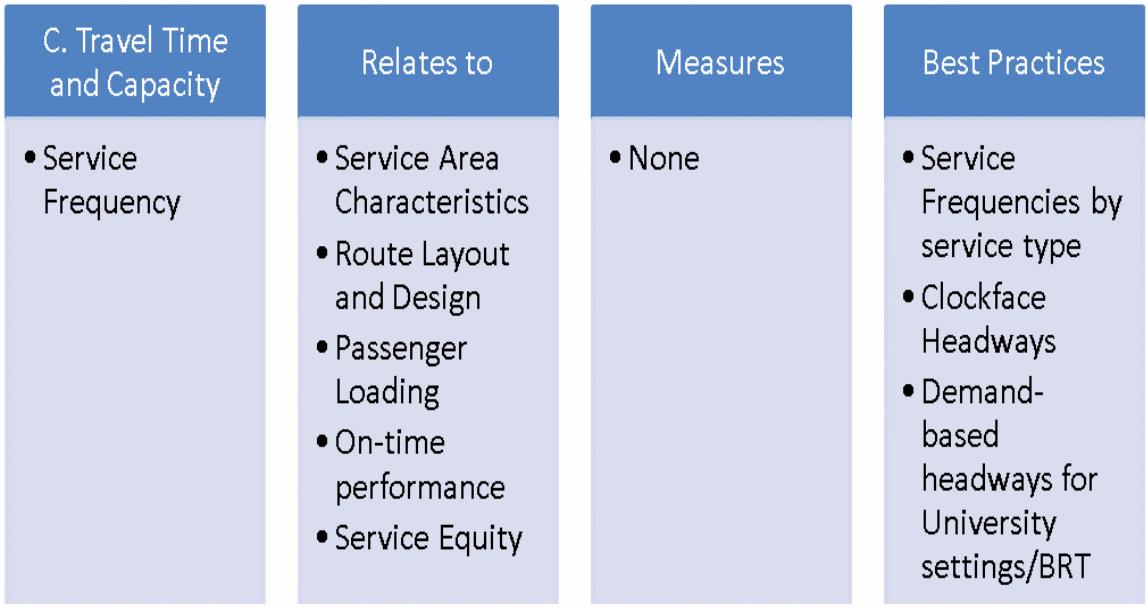


Figure 5-5 Service Frequency

Service directness standards are used by some agencies in the industry (35 %, as revealed in the survey) to assure that routes operate as directly as possible to maximize average speed and minimize travel time. Service directness has an inverse relationship with service coverage and therefore compromises must often be made to balance the need for directness versus coverage. Typically, this involves a time standard that a deviation (a segment of the route that is not the most direct) may not exceed. Some agencies even require a certain number of passengers to be picked up on the deviation to justify the added time required to make the deviation. Another measure of service directness is the number of transfers that a rider has to make to reach his final destination. A certain maximum percentage of riders that require a transfer may be specified as a standard. As a strategy to reduce transfers, agencies may use interlining, which involves having two separate routes that have a common transfer location to operate on both routes, allowing passengers to remain onboard.

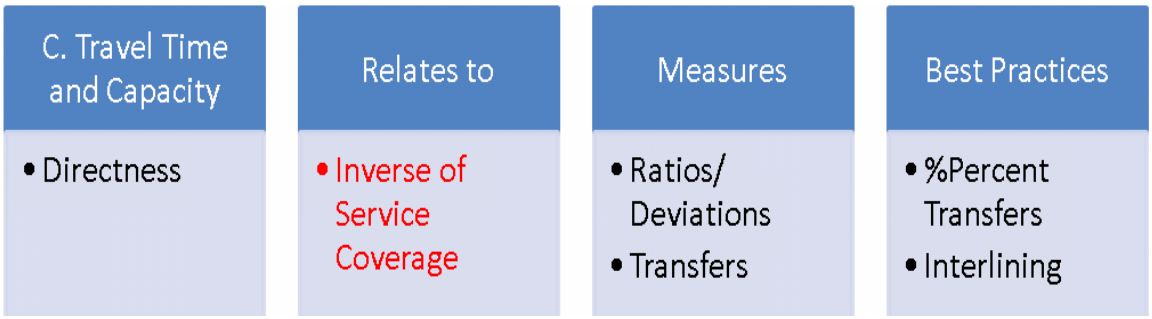


Figure 5-6 Service Directness

Span of service is another area in which agencies may apply specific standards. Every agency must define a span of service for each of its services. How this is done is typically based on perceived demand for the service and available resources. Typically, different service types will have varying spans of service. For example, express buses generally operate fewer trips and may only operate in the morning and the evening as a commuter service. Finally, span of service will likely vary based on the day of the week, with weekday service being longer than Saturday and Sundays. Some agencies have defined standards on how they determine changes to their span of service. One such example is that the span can be increased if the earlier or later trip performs better than 50 percent of the system average in passengers per revenue hour. Another example is a shift in employee business hours for an existing or new major employment center. Standards can also been applied to determine the length of Saturday and Sunday service in respect to weekday service spans or specific weekend activity.

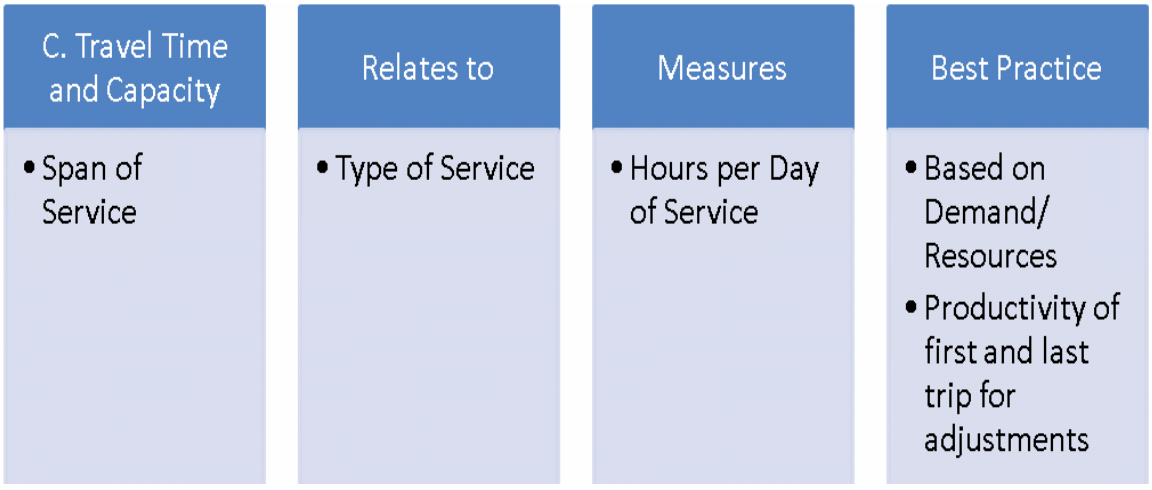


Figure 5-7 Span of Service

Loading standards are used by agencies to limit the number of standees or not allow for standees. Standees are typically undesirable by agencies as they make it more uncomfortable for the passengers. Standees are not particularly a problem for a core route in a system, but rather for services such as express routes or Bus Rapid Transit (which have high passenger loads) or during peak hours. Therefore, an agency will likely need to set up loading standards only for specific types of service or specific times of day. Another consideration for loading standards is areas with active university systems. If the system is used heavily by the students, then it would be advisable to have specific standards for these systems.

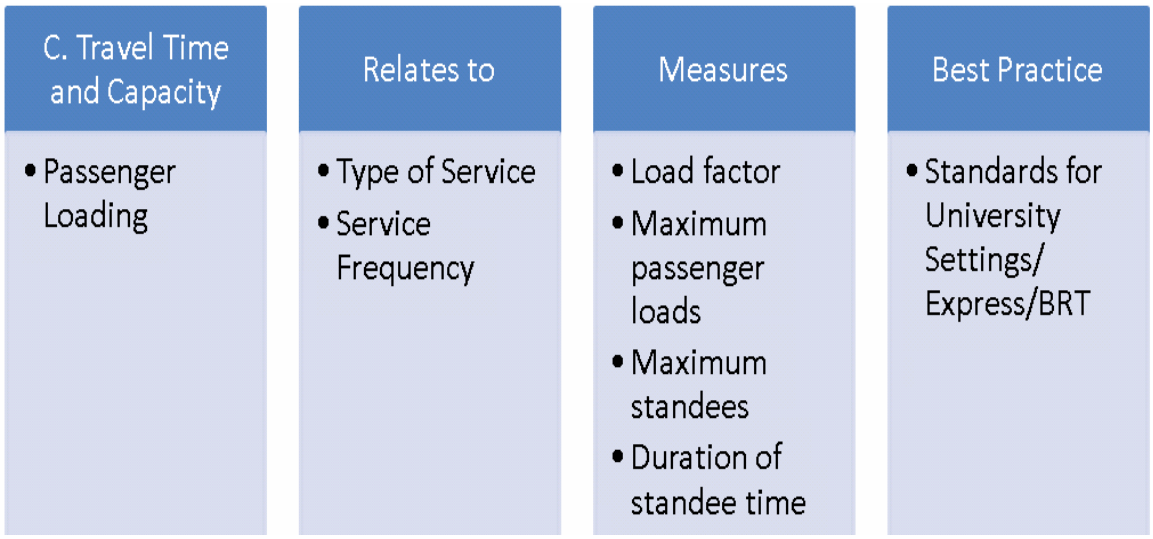


Figure 5-8 Passenger Loading

D. Service Delivery (impact on customers)

Agencies may set specific standards that have a direct impact on customers using the service. They include such aspects as on-time performance, passenger shelters and other amenities, customer service and safety issues. A majority of agencies surveyed (76%) stated that they use service delivery standards.

On-time performance is typically defined as a bus being late by more than five minutes or early by one minute. Some agencies may set stricter standards such as not more than three minutes or no acceptance of early buses at all. The other aspect of on-time performance standards is typically a percentage of trips that must meet the time standard. Because the time standard will vary from agency to agency, the percentage required on-time will also vary. From the literature review, this percentage varied from 60 to 95 percent. Furthermore, agencies may use multiple percentage standards based on the time of day (peak versus non-peak) or the service frequency of each route. Agencies that have APC

technology will have an easier time tracking on-time performance versus agencies that have to use frequent ride checks.

D. Service Delivery	Relates to	Measures	Best Practice
• On-time performance	• Type of Service • Service Frequency	• Percent on-time • Minutes early/late	• APC tracking

Figure 5-9 On Time Performance

Passenger shelters and other amenities is another area of service delivery that benefits from having standards. Typically, this will involve the number of boardings or transfers made at each individual stop. This value will vary from agency to agency based on the relative performance of the system and available funding for shelters and amenities. Once again, APC can be a very useful tool to show an agency which stops have the highest boardings. Other considerations may include the average wait time between buses, the number of bus lines, service to specific facilities, or protection from weather elements. Other standards in reference to shelters may include feasibility of installing at a certain location and proper lighting.

D. Service Delivery	Relates to	Measures	Best Practice
• Passenger shelters/ Amenities	• Type of Service • Service Frequency	• Boardings/ transfers • Average wait time	• APC analysis

Figure 5-10 Passenger Shelters/Amenities

Customer service concerns are best addressed by passenger surveys. However, some agencies track the number of complaints they receive and set a standard regarding complaints per passengers served. ***Safety issue*** standards are typically limited to the rate of accidents, with a maximum allowable number based on a certain amount of vehicle miles operated (a common measure used is accidents per 100,000 vehicle miles). Safety standards directly relate to the reliability and condition of the fleet. A younger and more reliable fleet will be more likely to meet specified safety standards.

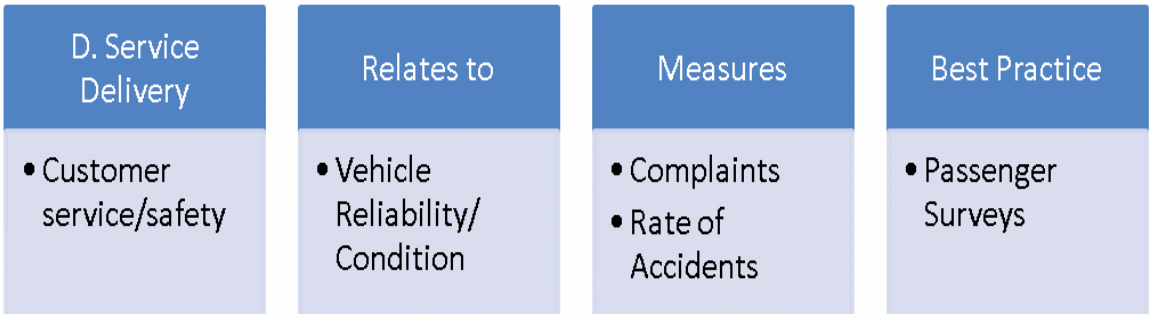


Figure 5-11 Customer Service/Safety

E. Vehicle Standards (impact on fleet)

Another area that agencies may employ standards is with their fleet. This includes assignment of vehicles, utilization and efficiency, and reliability and condition. According to the survey, 73 percent of agencies use some sort of vehicle standards. The ***assignment of vehicles*** is fairly straightforward – smaller vehicles are assigned to routes with fewer riders, medium-sized vehicles are used for core routes, and larger vehicles such as articulated buses are appropriate for limited stop and express services. Agencies that use APC will also need specific standards for how those buses are distributed among the system.

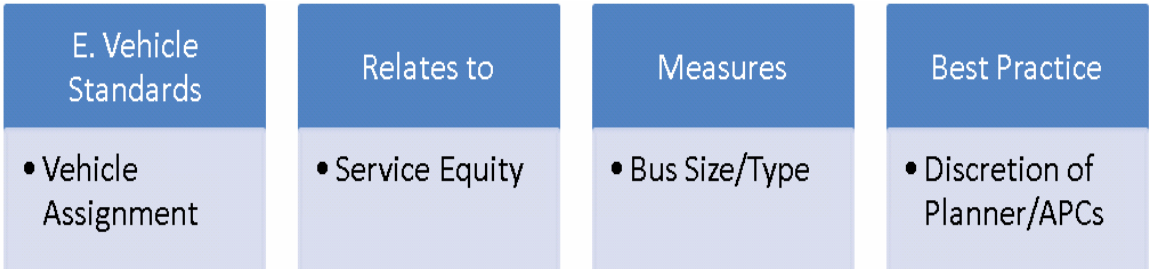


Figure 5-12 Vehicle Standards

Vehicle utilization and efficiencies typically are measured in performance monitoring programs and are rarely used for specific standards. These measures will be discussed in the performance measurement section.

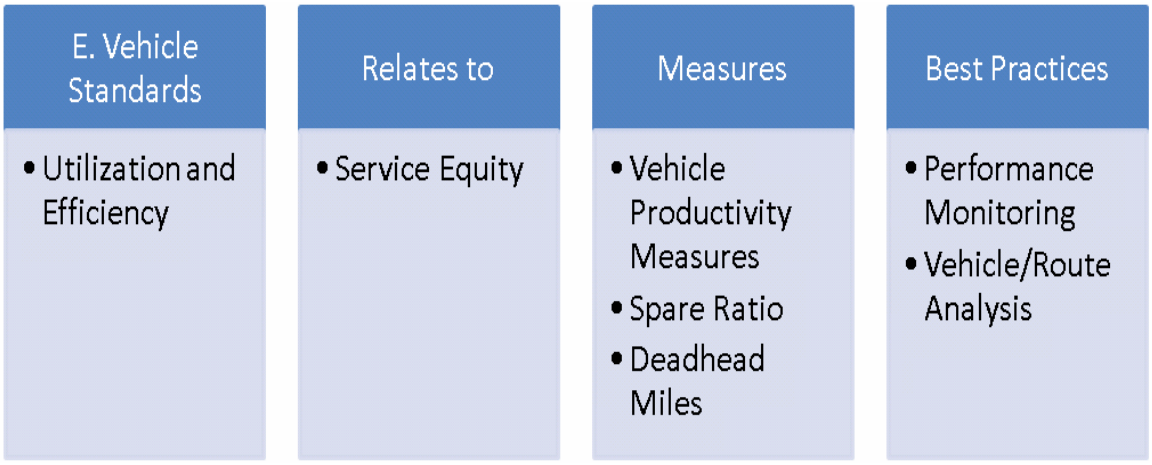


Figure 5-13 Vehicle Utilization and Efficiency

Vehicle reliability and condition standards include a certain number of vehicle miles between road calls, the average age of the fleet and the service life of vehicles (in years and miles).

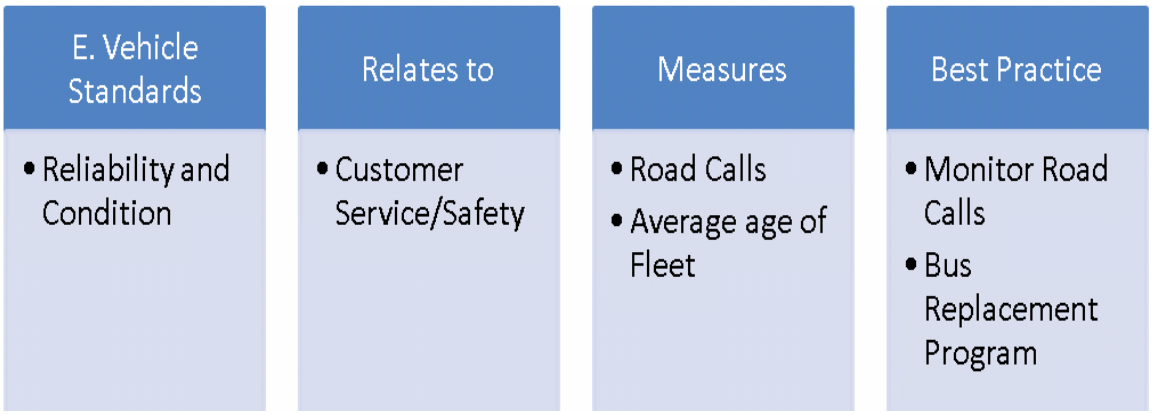


Figure 5-14 Vehicle Reliability and Condition

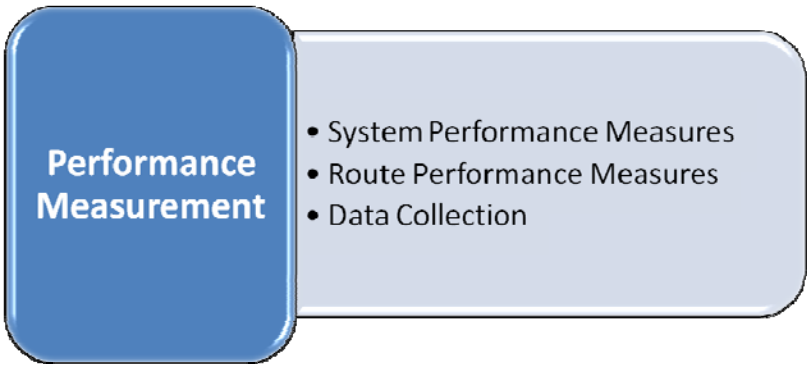
F. Service Equity

Service equity refers to the equitable distribution of services for all population groups, especially minority populations. Title VI of the Civil Rights Act of 1964 governs service equity and, therefore, the FTA Civil Rights Office should be consulted to ensure your agencies compliance with the FTA Title VI requirements.

F. Service Equity	Relates to	Measures	Best Practice
• FTA Required Standards	• Passenger Loadings • Vehicle Assignment • Service Frequency • Passenger Shelters • Transit Access	• n/a	• n/a

Figure 5-15 Service Equity

Performance Measures



Transit agencies routinely collect a variety of performance measures at both a system and individual route level throughout their agencies. As implied, system-level data are collected and compiled at the aggregate level and encompass a multitude of data sources and items. Route-level performance data, on the other hand, are usually limited to collecting and compiling a limited set of data to keep the collection and compilation process manageable.

On a system level, performance measures are used to:

- submit to the National Transit Database as a requirement for receiving funding from FTA
- assist agencies in monitoring the various trends of the agency for operational and financial measures and also to compare their performance to peer agencies
- define service design standards, as described in Part I of this literature review

An example of the types of information routinely collected, calculated, and published at the system level are depicted in Table 5-2.

On an individual route level, performance measures are used to:

- perform a Comprehensive Operations Analysis (COA)
- define performance standards
- monitor performance to measure against the system average or defined standards

Table 5-2

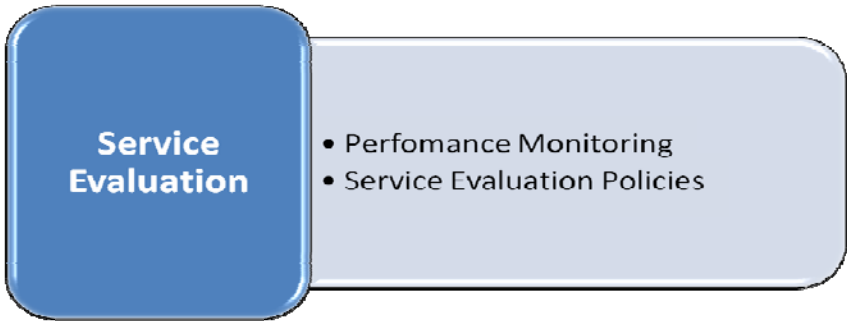
Typical System-Level Performance Data and Measures

Operational Measures	Financial Measures
Service	***Expense and Revenue***
Service Area Population	Operating Expenses
Service Area Density	Maintenance Expenses
Passenger Trips	Local Revenue
Passenger Miles	Local Contribution
Average Passenger Trip Length	Passenger Fare Revenue
Revenue Miles	Other Non-Fare Revenue
Revenue Hours	Average Fare
Vehicle	***Efficiency***
Vehicles Available in Maximum Service	Operating Expense per Capita
Vehicles Operated in Maximum Service (VOMS)	Operating Expense per Passenger Trip
Revenue Miles per Vehicle in Maximum Service	Operating Expense per Revenue Mile
Average Age of Fleet (in yrs)	Operating Expense per Revenue Hour
	Maintenance Expense per Revenue Hour
Employee	Maintenance Expense per VOMS
Total Employee FTEs	Farebox Recovery
Revenue Hours per Employee FTE	
Passenger Trips per Employee FTE	
Effectiveness	
Vehicle Miles per Capita	
Passenger Trips per Capita	
Passenger Trips per VOMS	
Passenger Trips per Revenue Mile	
Passenger Trips per Revenue Hour	

The typical route-level data components and resulting route-level performance measures are:

- **Route-Level Data**: passengers, revenue hours, revenue miles, and revenue collected
- **Route-Level Performance Measures:** passengers per revenue hour, passengers per revenue mile, subsidy per passenger trip, and farebox recovery

Service Evaluation Methodology



Identifying service design standards and compiling system- and route-level performance measures, while beneficial on their own merits, is not the final step in performance monitoring and service evaluation. To realize the benefit of the first two components of an effective transit service planning approach, the transit agency must define and routinely follow an effective and efficient service evaluation process.

A strong performance monitoring program ensures that service quality will be as high as possible. Service quality and quantity by route/service should be evaluated on a regular basis. Larger systems may evaluate their performance on a quarterly or even monthly basis, but smaller systems may find a semi-annual or annual report adequate.

In addition to full-scale service evaluation, it is common practice for agencies to track performance data on a monthly basis, especially ridership data. This will aid in the identification of poorly-performing services as well services that are performing well. The former may be candidates for service revision or elimination, while the latter may benefit from service improvements. Continuous monitoring of ridership data will provide the agency with the capability to track long-term changes in the system's performance and identify trends, which will lead to better service planning decisions.

System-Level Performance Monitoring

System-level performance monitoring can be accomplished by systematically using the performance measures developed. The data can be summarized over a specific time frame, commonly the most recent five-year period, to identify trends in each measure. Another effective analysis tool is to plot the system-level data to graphically display year-to-year trends. System-level performance monitoring should be done on an annual basis, at a minimum.

Two examples of system-level performance monitoring techniques are presented. The first examples are shown in Tables 5-3 and 5-4, which display a typical transit agency's performance data and measures for a five-year period.

Table 5-3
Typical System-Level Operational Performance Monitoring

Measure	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	% Change 2002-2006
Service Area Population	278,144	285,486	231,450	296,385	300,000	7.9%
Service Area Density	1,030	1,057	732	1,098	1,111	7.9%
Passenger Trips	947,768	1,195,449	1,241,334	1,304,637	1,692,093	78.5%
Passenger Miles	3,819,505	4,833,811	5,014,989	5,270,733	7,253,158	89.9%
Average Passenger Trip Length	4.03	4.04	4.04	4.04	4.29	6.4%
Revenue Miles	820,406	937,709	960,480	1,003,940	1,021,023	24.5%
Revenue Hours	56,207	82,517	75,287	82,600	85,127	51.5%
Vehicles Available	18	22	22	25	29	61.1%
Vehicles Operated in Maximum Service	15	15	16	19	18	20.0%
Revenue Miles per Vehicle in Maximum Service	54,694	62,514	60,030	52,839	56,724	3.7%
Average Age of Fleet (yrs)	5.24	5.45	4.36	5.08	5.60	6.9%
Total Employee FTEs	42.45	47.50	50.98	56.70	56.78	33.7%
Revenue Hours per Employee FTE	1,324	1,737	1,477	1,457	1,499	13.2%
Passenger Trips per Employee FTE	22,327	25,167	24,349	23,009	29,803	33.5%
Vehicle Miles per Capita	3.19	3.88	4.45	3.64	3.63	13.9%
Passenger Trips per Capita	3.41	4.19	5.36	4.40	5.64	65.5%
Passenger Trips per VOMS	63,185	79,697	77,583	68,665	94,005	48.8%
Passenger Trips per Revenue Mile	1.16	1.27	1.29	1.30	1.66	43.5%
Passenger Trips per Revenue Hour	16.86	14.49	16.49	15.80	19.88	17.9%

Table 5-4
Typical System-Level Financial Performance Monitoring

Measure	*FY 2002*	FY 2003	FY 2004	FY 2005	FY 2006	% Change 2002-2006
Operating Expense	$2,999,841	$3,556,510	$4,139,874	$5,137,999	$5,561,333	85.4%
Maintenance Expense	$721,619	$860,819	$995,391	$1,316,429	$1,055,803	46.3%
Local Revenue	$3,851,529	$2,826,777	$3,307,194	$4,322,960	$4,706,564	22.2%
**Local Contribution*	*$1,959,229*	*$1,873,196*	*$2,445,391*	*$3,433,715*	*$3,875,453*	*97.8%*
**Passenger Fare Rev.*	*$332,997*	*$391,155*	*$419,046*	*$492,031*	*$521,030*	*56.5%*
**Other Non-Fare Rev.*	*$1,559,303*	*$562,426*	*$442,757*	*$397,214*	*$310,081*	*-80.1%*
Average Fare	$0.35	$0.33	$0.34	$0.38	$0.31	-12.4%
Operating Expense Per Capita	$10.79	$12.49	$17.89	$17.34	$18.54	71.9%
Operating Expense Per Passenger Trip	$3.17	$2.98	$3.34	$3.94	$3.29	3.8%
Operating Expense Per Revenue Mile	$3.66	$3.80	$4.31	$5.12	$5.45	49.0%
Operating Expense Per Revenue Hour	$53.37	$43.22	$54.99	$62.20	$65.33	22.4%
Maintenance Expense Per Revenue Hour	$12.84	$10.43	$13.22	$15.94	$12.40	-3.4%
Maintenance Expense Per Vehicle in Maximum Service	$48.11	$57.39	$62.21	$69.29	$58.66	21.9%
Farebox Recovery	11.1%	11.0%	10.1%	9.6%	9.4%	-15.6%

The second is a trend analysis graphic display that can be developed for each of the performance data and measures that the agency has captured.

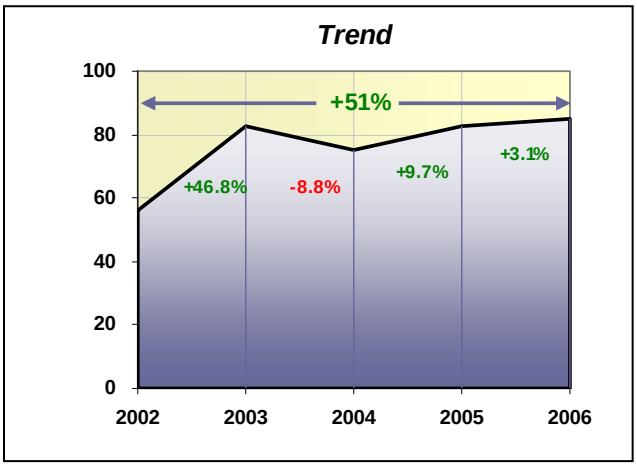


Figure 5-16 Revenue Hour Trends

Route-Level Performance Monitoring

The typical route-level data components and resulting route-level performance measures are:

- **Route-Level Data**: passengers, revenue hours, revenue miles, and revenue collected
- **Route-Level Performance Measures:** passengers per revenue hour, passengers per revenue mile, subsidy per passenger trip, and farebox recovery

Based upon the size and sophistication of the transit agency, route-level performance monitoring may be undertaken for each type of service provided (e.g., trunk routes, cross-town services, express service, BRT service, etc.).

The route-level performance process is usually based upon productivity performance measures instead of just route-level data. With the use the performance measures, variations in number of buses assigned to the route, service span, and route length can be factored out of the analysis.

Service Evaluation Policies

The final, but very critical, step in the transit service planning process is to set up specific protocol and policies for the agency to evaluate and objectively address route level performance – both negative and positive. Section III-B in Chapter provides many examples of approaches and policies adopted by various transit agencies to evaluate service.

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APPENDIX

Glossary of Transit Service Planning Terminology

Glossary of Transit Service Planning Terminology

Absolute Performance Measures

Performance measures where the performance of a route is measured against some predetermined standard.

Actual Vehicle Miles/Hours

The miles/hours a vehicle travels while in revenue service (actual vehicle revenue miles/hours) plus deadhead miles/hours. For rail vehicles, vehicle miles/hours refer to passenger car miles/hours. Actual vehicle miles/hours exclude miles and hours for charter services, school bus service, operator training and maintenance testing.

Americans with Disabilities Act (ADA)

Federal legislation passed in 1991 defining the responsibilities of and requirements for transportation providers to make transportation accessible to people with disabilities. This law assures that people with disabilities have full access to all public facilities throughout the United States. Standards for improvements such as wheelchair ramps have been established in accordance with the act. All new development and redevelopment plans must be in compliance with the requirements set forth by the act.

AM Peak Period

The period of time in the morning when additional services are provided to handle higher passenger volumes. The period begins when normal, scheduled headways are reduced and ends when headways return to normal.

Arterial Street

A major thoroughfare used primarily for through traffic rather than for access to adjacent land, characterized by high vehicular capacity and continuity of movement.

Articulated Bus

A bus usually 55 foot or more in length with two connected passenger compartments, which bends at the connecting point when the bus turns a corner.

Base Fare

The price charged to one adult for one transit ride; excludes transfer charges, zone charges, express service charges, peak period surcharges, and reduced fares.

Base Period

The period between the morning and evening peak periods when transit service is generally scheduled on a constant interval. Also known as "off-peak period."

Bus (Motorbus)

A rubber-tired, self-propelled, manually-steered vehicle with fuel supply carried on board the vehicle. Types include advanced design, articulated, charter, circulator, double deck, express, feeder, intercity, medium-size, new look, sightseeing, small, standard-size, subscription, suburban, transit , and van.

Bus, Medium-Size

A bus from 29 to 34 foot in length.

Bus, Small

A bus 28 foot or less in length.

Bus, Standard-Size

A bus from 35 to 41 foot in length.

Bus, Transit

A bus with front and center doors, normally with a rear-mounted engine and low-back seating, and without luggage compartments or restroom facilities for use in frequent-stop service.

Bus, Trolley

An electric, rubber-tired transit vehicle, manually steered, propelled by a motor drawing current through overhead wires from a central power source not on board the vehicle. Also known as "trolley coach" or "trackless trolley."

Bus Bay

A specially-designed or designated location at a transit stop, station, terminal, or transit center at which a bus stops to allow passengers to board and alight.

Bus Bulb

An arrangement by which a sidewalk is extended outwards for a bus stop; typically, a bus bulb replaces roadway that would otherwise be part of a parking lane. With bus bulbs, a bus can stay in its traffic lane to discharge and pick up passengers instead of having to pull over to the curb.

Bus Rapid Transit (BRT)

BRT provides exclusive or semi-exclusive rights-of-way for buses or bus-like vehicles. Exclusive busways function like rail transit in that they are constructed with passenger stations and offer a degree of physical separation from mixed vehicular traffic. In non-exclusive rights-of-way, buses are required to stop for street traffic signals. BRT vehicles are rubber-tired and can use a guidance system that allows for accurate docking at stations.

Bus Shelter

A building or other structure constructed near a bus stop to provide seating and protection from the weather for the convenience of waiting passengers.

Bus Stop

A place at which passengers can board or alight from the bus, usually identified by a sign. Bus stops are placed in one of three locations: near-side (located immediately before an intersection); far-side (located immediately after an intersection); and mid-block (located between intersections).

Bus Stop Spacing

Bus stops are usually located to provide a balance of bus passenger convenience and vehicle operating efficiency. Having too many bus stops along a bus line results in slow and unreliable service, whereas too few bus stops means that many passengers will have to walk a long way to get to their bus. A number of research efforts have concluded that the optimal bus stop spacing for most regular transit routes is somewhere between 1,000-2,000 feet (300-600m).

Bus Turnout

A bus turnout, bus pullout, or bus bay is a special zone on the side of the main roadway for primarily buses to stop for a designated bus stop in order to pick up and drop off passengers. The purpose of the bus turnout is to avoid blocking a lane of traffic and to improve passenger safety during boarding and alighting.

Busway

An exclusive freeway lane for buses and sometimes carpools.

Capacity

Maximum number of riders that a transit line or system can carry, measured in riders per hour past a designated point in one direction.

Central Business District (CBD)

The downtown retail trade and commercial area of a city or an area of very high land valuation, traffic flow, and concentration of retail business offices, theaters, hotels, and services.

Circulator Route

A bus serving an area confined to a specific locale, such as a downtown area or suburban neighborhood with connections to major traffic corridors.

Clock Headways

Development of transit schedules to provide service at regular intervals that are repeated hourly (e.g., 10 minutes, 15 minutes, 30 minutes, and 60 minutes) to make schedules easy for patrons to remember. Clock headways are sometimes referred to as clock face.

Collector Street

Roadway that serves internal traffic movements in an area by connecting several local streets with an arterial roadway

Crosstown Route

Non-radial bus or rail service that does not enter the Central Business District (CBD).

Cycle Time

The total time required for a transit vehicle to complete one round trip on its route, including all station dwell times and time for layover at terminals.

Deadhead

Miles and hours that a vehicle travels when out of revenue service. This includes leaving and returning to the garage, changing routes, etc., and times when there is no reasonable expectation of carrying revenue passengers. However, it does not include charter service, school bus service, operator training, maintenance training, etc. For non-scheduled, non-fixed-

route service (demand-responsive), deadhead mileage also includes the travel between the dispatching point and passenger pick-up or drop-off.

Deviated Fixed-Route Service

Any system of transporting individuals, including the provision of designated public transportation service by public entities and the provision of transportation service by private entities, including, but not limited to, specific public transportation service which is not a fixed-route system.

Dwell Time

The scheduled time a vehicle or train is allowed to discharge and take on passengers at a stop, including opening and closing doors.

Employment Density

The number of employees per square mile, acre or square kilometer.

Express Route

A bus that operates a portion of the route without stops or with a limited number of stops.

Fare Box Recovery Ratio

Measure of the proportion of operating expenses covered by passenger fares; found by dividing fare box revenue by total operating expenses for each mode and/or systemwide.

Fare Box Revenue

Value of cash, tickets, tokens, and pass receipts given by passengers as payment for rides; excludes charter revenue.

Fare Box Revenue per Passenger

A financial performance indicator that is influenced by number of riders, fare structure, rider profile, and transfer rate. For example, a low regular fare and a large number of riders eligible for discounted fares, coupled with a high transfer rate, would result in low farebox revenue per passenger.

Fare Box Revenue per Total Expenses

A financial performance indicator of the users' share of the total cost of service. A higher number is more favorable. Factors that affect this indicator are the amount of the base fare, number of riders, number of passengers eligible for a discounted fare, and ability to sell advertising.

Fare Elasticity

The extent to which ridership responds to fare increases or decreases.

Fare Structure

The system set up to determine how much is to be paid by various passengers using a transit vehicle at any given time.

Feeder Route

A bus service that picks up and delivers passengers to a rail rapid transit station or express bus stop or terminal.

Fixed Cost

An indirect cost that remains relatively constant, irrespective of the level of operational activity.

Fixed Route

Service provided on a repetitive, fixed-schedule basis along a specific route with vehicles stopping to pick up and deliver passengers to specific locations; each fixed-route trip serves the same origins and destinations, unlike demand responsive and taxicabs.

Flag Stop

Intercity bus or commuter rail transportation stops that are not bus stops or stations with regularly scheduled stops but at which buses or trains will stop to board or alight passengers only by advanced signal or notice. Also used to pick up passengers usually in rural areas with no official bus stop locations.

Headway

Time interval between vehicles moving in the same direction on a particular route.

Intercity Bus

A bus with front doors only, high-backed seats, and separate luggage compartments, and usually with restroom facilities for use in high-speed long-distance service.

Interlining

Refers to a bus that serves two or more routes with common terminals during a single trip.

Intermodal

Those issues or activities that involve or affect more than one mode of transportation, including transportation connections, choices, cooperation, and coordination of various modes. Also known as "multimodal."

Layover Time (Recovery Time)

Time built into a schedule between arrival at the end of a route and the departure for the return trip, used for the recovery of delays and preparation for the return trip.

Level of Service (LOS)

A set of characteristics that indicates the quality and quantity of transportation service provided, including characteristics that are quantifiable and those that are difficult to quantify. For paratransit services, level of service represents a variety of measures meant to denote the quality of service provided, generally in terms of total travel time or specific component of travel time.

Linked Trip

A trip from origin to destination on the transit system. Even if a passenger must make several transfers during a journey, the trip is counted as one linked trip on the system.

Load Factor

The ratio of passengers actually carried versus the total passenger capacity of a vehicle.

Local Street

Roadways that provide direct access to the adjacent land. The roadway typically accommodates a low volume of traffic.

Midday Period

The period of time between the end of the AM peak and the beginning of the PM peak.

Missed Trip (Fixed Route)

Occurs when a transit vehicle does not arrive at its scheduled bus stops due to service interruption usually caused by an incident or accident.

Monorail

An electric railway in which a rail car or train of cars is suspended from or straddles a guideway formed by a single beam or rail. Most monorails are either heavy rail or automated guideway systems.

National Transit Database (NTD)

A reporting system, by uniform categories, to accumulate mass transportation financial and operating information and a uniform system of accounts and records.

Off-Peak Period

Non-rush periods of the day when travel activity is generally lower and less transit service is scheduled. Also called "base period."

On-Time Performance

The transit industry defines on-time performance as the percentage of trips which arrive/depart within a specified time frame at a specific published time point.

Operating Expense

Monies paid in salaries, wages, materials, supplies, and equipment in order to maintain equipment and buildings, operate vehicles, rent equipment and facilities, and settle claims.

Operating Revenue

Receipts derived from or for the operation of transit service, including fare box revenue, revenue from advertising, interest, and charter bus service, and operating assistance from governments.

Owl Service

Bus service that operates through the nighttime hours. Many cities operate such services, in substitution for either ordinary daytime bus services or metro/subway rail services. Owl or night bus service is much more limited than daytime bus service and provides fewer lines and reduced frequency.

Paratransit

Comparable transportation service required by the Americans with Disabilities Act for people with disabilities who are unable to use fixed-route transportation systems.

Park-and-Ride Lot

Designated parking areas for automobile drivers who then board transit vehicles from these locations.

Passenger

Any occupant of a motor vehicle (in or upon the vehicle) who is not the driver.

Passenger Count

The total number of passengers over a period of time who use a particular facility or service.

Passenger Flow

The number of passengers who pass a given location in a specified direction during a given period.

Passenger Miles

The total number of miles traveled by passengers on transit vehicles; determined by multiplying the number of unlinked passenger trips by the average length of their trips.

Passengers per Bus Hour

An effectiveness indicator that measures service utilization. It is affected by service hours, service design, and service area characteristics. A system may carry a high number of passengers per mile but a relatively low number of passengers per bus hour if vehicles operate in congested areas and thus travel at slower speeds.

Passengers per Bus Mile

An effectiveness indicator that measures service utilization. A higher number is more favorable. Service area characteristics and service design impact this indicator. For example, a transit system serving a community with a widely dispersed population must operate circuitous routes that tend to carry fewer passengers per mile.

Passenger Revenue

Money, including fares and transfer, zone, and park-and-ride receipts, paid by transit passengers; also known as "farebox revenue."

Peak Period

Morning and afternoon time periods when transit riding is heaviest.

Peak/Base Ratio

The number of vehicles operated in passenger service during the peak period divided by the number operated during the base period.

PM Peak Period

The period in the afternoon or evening when additional services are provided to handle higher passenger volumes. The period begins when normal headways are reduced and ends when headways are returned to normal.

Population Density

The total population within a geographic entity divided by the number of square miles ((or square kilometers) of land area of that entity measured in square kilometers or square miles.

Public Transit System

An organization that provides transportation services owned, operated, or subsidized by any municipality, county, regional authority, state, or other governmental agency, including those operated or managed by a private management firm under contract to the government agency owner.

Public Transportation

Transportation by bus, rail, or other conveyance, either publicly or privately owned, which provides to the public general or special service on a regular and continuing basis. Also known as "mass transportation," "mass transit," and "transit."

Rail, Commuter

Railroad local and regional passenger train operations between a central city, its suburbs, and/or another central city. It may be either locomotive-hauled or self-propelled and is characterized by multi-trip tickets, specific station-to-station fares, railroad employment

practices and usually only one or two stations in the central business district. Also known as "suburban rail."

Rail, Heavy

An electric railway with the capacity for a "heavy volume" of traffic and characterized by exclusive rights-of-way, multi-car trains, high speed, and rapid acceleration, sophisticated signaling, and high platform loading. Also known as "rapid rail," "subway," "elevated (railway)," or "metropolitan railway (metro)."

Rail, High Speed

A rail transportation system with exclusive right-of-way that serves densely-traveled corridors at speeds of 124 mph (200 km/h) and greater.

Rail, Light

An electric railway with a "light volume" traffic capacity compared to heavy rail. Light rail may use shared or exclusive rights-of-way, high or low platform loading and multi-car trains or single cars. Also known as "streetcar," "trolley car," and "tramway."

Rapid Transit

Rail or motorbus transit service operating completely separate from all modes of transportation on an exclusive right-of-way.

Relative Performance Measures

Performance measures in which the performance of a route is measured against the performance of other routes.

Revenue Seat Mile

The movement of one transit passenger seat the distance of one mile. Obtained by multiplying the number of revenue seats in the vehicle by the number of miles traveled.

Revenue Service

The times when a vehicle is available to the general public and there is a reasonable expectation of carrying passengers that either directly pay fares, are assisted by public policy, or provide payment through some contractual arrangement. Vehicles operated in fare-free service are considered to be in revenue service. Revenue service excludes deadhead, school bus, and charter services.

Revenue Vehicle Mile

The distance in miles that a revenue vehicle is operated while it is available for passenger service.

Revenue Vehicles

The fleet and rolling stock used in providing transit service for passengers.

Ridership

The number of rides taken by people using a public transportation system in a given time period.

Route Deviation

Service is provided at fixed time/location stops, while also providing an on-demand service to customers off the standard route. Real-time scheduling and dispatching are a significant challenge in route-deviation service due to the high demand at fixed stops, the large volume of requests for deviations, and the dynamics of buses schedule adherence.

Route Miles

The total number of miles included in a fixed route transit system network.

Scheduled Revenue Service

The total service scheduled to be provided for picking up and discharging passengers. Scheduled revenue service is computed from internal transit agency planning documents (e.g., run paddles, trip tickets, and public timetables) and includes the whole trip (e.g., deadhead, layover/recovery, and actual picking up and discharging of passengers). Schedule service excludes service interruptions and special additional services.

Scheduled Service

A scheduled commercial passenger vehicle trip. The scheduled trip generally is offered at pre-established times between designated locations. Also the total service scheduled, computed from schedules. Scheduled service excludes service interruptions and special additional services.

Service Area

A defined area from within which the majority of transit users will travel. A service area is influenced by the level of transit service provided, destinations served, availability of adequate parking, quality and convenience of vehicular access and intermodal transfers, and the relative location and quality of other nearby competing transit facilities.

Service Availability

Measures the passenger's ability to access and use transit.

Service Consumed

The amount of service actually used by passengers, measured by unlinked passenger trips and passenger miles.

Service Coverage

Measures the extent to which the defined service area is being served

Service Directness

The degree to which a route deviates from the shortest path between the start and end points of the route.

Service Frequency

How often buses arrive at a particular stop.

Service Route

Another hybrid between fixed-route and demand-response service. Service routes are established between targeted neighborhoods and service areas riders want to reach. Similar to deviated fixed routes, service routes are characterized by flexibility and deviation from fixed-route intervals. However, while deviated fixed routes require advanced reservations, service routes do not. A service route can include both regular, predetermined bus stops and/or allow riders to hail/flag the vehicle and request a drop-off/pick-up anywhere along the route.

Service Supplied

The amount of service actually made available to prospective passengers. Measured in vehicles, miles, and/or hours that were operated during a given period.

Service Vehicles

Rolling stock or fleet vehicles used in connection with keeping revenue vehicles in operation.

Shuttle

A public or private vehicle that travels back and forth over a particular route, especially a short route or one that provides connections between transportation systems, employment centers, etc.

Span of Service

The hours and days during which service operates.

Standee

A transit passenger who stands on a vehicle due to the unavailability of seats.

Subsidy Cost

The estimated long-term cost to the local or federal government of providing credit assistance (e.g., direct loans or loan guarantees), calculated on a net present value basis at the time of disbursement and excluding administrative costs.

Transfer Center

A fixed location at which passengers change from one route or vehicle to another.

Transit System

An organization (public or private) providing local or regional multi-occupancy-vehicle passenger service.

Unlinked Passenger Trips

The number of passengers who board public transportation vehicles. Passengers are counted each time they board vehicles, no matter how many vehicles they use to travel from their origin to their destination.

Wheelchair Accessible Vehicle

A vehicle that a person using a wheelchair may enter, either via an on-board retractable lift or ramp or directly from a station platform that is accessible by elevator or a ramp that is either level with the vehicle floor or can be raised to floor level.