TCRP
REPORT 88

TRANSIT
COOPERATIVE
RESEARCH
PROGRAM

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A Guidebook for Developing a Transit Performance-Measurement System

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TRANSIT COOPERATIVE RESEARCH PROGRAM

TCRP REPORT 88

A Guidebook for Developing a Transit Performance-Measurement System

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TRANSIT COOPERATIVE RESEARCH PROGRAM

The nation's growth and the need to meet mobility, environmental, and energy objectives place demands on public transit systems. Current systems, some of which are old and in need of upgrading, must expand service area, increase service frequency, and improve efficiency to serve these demands. Research is necessary to solve operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the transit industry. The Transit Cooperative Research Program (TCRP) serves as one of the principal means by which the transit industry can develop innovative near-term solutions to meet demands placed on it.

The need for TCRP was originally identified in *TRB Special Report 213—Research for Public Transit: New Directions,* published in 1987 and based on a study sponsored by the Urban Mass Transportation Administration—now the Federal Transit Administration (FTA). A report by the American Public Transportation Association (APTA), *Transportation 2000*, also recognized the need for local, problem-solving research. TCRP, modeled after the longstanding and successful National Cooperative Highway Research Program, undertakes research and other technical activities in response to the needs of transit service providers. The scope of TCRP includes a variety of transit research fields including planning, service configuration, equipment, facilities, operations, human resources, maintenance, policy, and administrative practices.

TCRP was established under FTA sponsorship in July 1992. Proposed by the U.S. Department of Transportation, TCRP was authorized as part of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). On May 13, 1992, a memorandum agreement outlining TCRP operating procedures was executed by the three cooperating organizations: FTA; the National Academies, acting through the Transportation Research Board (TRB); and the Transit Development Corporation, Inc. (TDC), a nonprofit educational and research organization established by APTA. TDC is responsible for forming the independent governing board, designated as the TCRP Oversight and Project Selection (TOPS) Committee.

Research problem statements for TCRP are solicited periodically but may be submitted to TRB by anyone at any time. It is the responsibility of the TOPS Committee to formulate the research program by identifying the highest priority projects. As part of the evaluation, the TOPS Committee defines funding levels and expected products.

Once selected, each project is assigned to an expert panel, appointed by the Transportation Research Board. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, TCRP project panels serve voluntarily without compensation.

Because research cannot have the desired impact if products fail to reach the intended audience, special emphasis is placed on disseminating TCRP results to the intended end users of the research: transit agencies, service providers, and suppliers. TRB provides a series of research reports, syntheses of transit practice, and other supporting material developed by TCRP research. APTA will arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by urban and rural transit industry practitioners.

The TCRP provides a forum where transit agencies can cooperatively address common operational problems. The TCRP results support and complement other ongoing transit research and training programs.

TCRP REPORT 88

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NOTICE

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The members of the technical advisory panel selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and while they have been accepted as appropriate by the technical panel, they are not necessarily those of the Transportation Research Board, the National Research Council, the Transit Development Corporation, or the Federal Transit Administration of the U.S. Department of Transportation.

Each report is reviewed and accepted for publication by the technical panel according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council.

Special Notice

The Transportation Research Board, the National Research Council, the Transit Development Corporation, and the Federal Transit Administration (sponsor of the Transit Cooperative Research Program) do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the clarity and completeness of the project reporting.

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The **Transportation Research Board** is a division of the National Research Council, which serves the National Academy of Sciences and the National Academy of Engineering. The Board's mission is to promote innovation and progress in transportation by stimulating and conducting research, facilitating the dissemination of information, and encouraging the implementation of research results. The Board's varied activities annually engage more than 4,000 engineers, scientists, and other transportation researchers and practitioners from the public and private sectors and academia, all of whom contribute their expertise in the public interest. The program is supported by state transportation departments, federal agencies including the component administrations of the U.S. Department of Transportation, and other organizations and individuals interested in the development of transportation. **www.TRB.org**

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FOREWORD

By Christopher W. Jenks
Staff Officer
Transportation Research Board

TCRP Report 88: A Guidebook for Developing a Transit Performance-Measurement System will be of interest to transit managers and others interested in developing or improving performance-measurement systems for transit agencies or incorporating transit performance measures into regional decision-making processes. The guidebook provides a step-by-step process for developing a performance-measurement program that includes both traditional and non-traditional performance indicators that address customer-oriented and community issues.

The guidebook begins with a discussion of the need for performance-measurement programs, discusses the importance of customer satisfaction, describes the characteristics of an effective performance-measurement system, and shows how performance measures are used by service industries in the private sector. Twelve case-study examples of successful performance-measurement programs are provided.

The guidebook also provides an eight-step process for implementing or updating a performance-measurement program. Each step includes a list of agency “things to do,” describes how to complete those action items, and provides examples of different approaches used by transit agencies in accomplishing that step. The guidebook discusses categories of performance measures that agencies may wish to consider, different types of measures that can be used, data sources and data collection and management techniques that can be employed, and methods of reporting results. Detailed summaries are presented for over 400 performance measures. To help agencies quickly find measures appropriate to their goals, objectives, and resources, selection menus guide users through a series of questions that lead to specific measures or families of measures. Finally, the guidebook provides a core set of suggested performance measures and offers a hypothetical application of the guidebook.

The guidebook contains an accompanying CD-ROM (*CRP-CD-25*) that includes an electronic version of the guidebook that is extensively hyperlinked, allowing users to jump immediately to related material and to navigate the performance measure selection menus. *CRP-CD-25* also includes a background document that includes additional case studies and an annotated bibliography of nearly 200 documents relating to transit performance measurement, a library of related TCRP documents, and other resources on performance measurement.

Much has been written about performance measurement in the transit industry. Many performance indicators and measures have been developed and used in a variety of ways in response to differing transit-system goals and objectives.

What has been lacking in the transit industry is a rigorous process for determining the most appropriate performance measures and indicators that should be used by a transit organization. In addition, traditional service efficiency indicators (e.g., operating expense per vehicle revenue mile and/or hour) and cost-effectiveness indicators (e.g., operating expense per passenger mile and/or passenger trip) are sometimes not linked to customer-oriented and community issues.

Research was needed to develop a process that can be used by transit systems to prepare a performance-measurement system that is sensitive to customer-oriented and community issues. This process should provide a context, or framework, to select and apply appropriate performance indicators and measures that are integral to transit-system decision making. The research should analyze the different dimensions along which agency performance can be defined, measured, and interpreted based on an operator's goals and objectives.

Under TCRP Project G-6, research was undertaken by Kittelson & Associates, Inc., to produce a practical, user-friendly guidebook to assist transit system managers in developing a performance-measurement system that uses traditional and nontraditional performance indicators and measures to address customer-oriented and community issues. The guidebook provides a menu of performance indicators and measures, describes how to select and implement the most appropriate performance indicators and measures, and explains how to incorporate the indicators and measures in the decision-making process to monitor and improve service.

To achieve the project objectives, the researchers first reviewed pertinent literature and research findings in the area of performance-measurement systems. Next, a list of performance indicators and measures used at domestic and international transit systems was developed that reflects the different types of transit systems operated (e.g., rail, bus, and paratransit). These indicators and measures were then categorized by functional type and were fully defined. An assessment of the usefulness of each was prepared.

The researchers then summarized the theory and practice of performance measurement in other relevant service industries, describing their key aspects and identifying performance indicators and measures that may have applicability in the transit industry. A number of nontraditional, community-, and customer-focused performance indicators and measures were then developed that might be appropriate for use by transit systems. A process was then developed to assist transit agencies in preparing a community- and customer-focused performance-measurement program.

On the basis of this material, a draft of the guidebook was developed. The draft was then reviewed by a focus group of general managers from transit systems of various sizes.

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The project team thanks the numerous organizations that participated in the case study interviews and the agency general managers and staff who provided feedback on the draft Guidebook. The feedback provided by the TCRP G-6 panel throughout the project is also gratefully acknowledged.

Abbreviations used without definitions in TRB publications:

AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ITE	Institute of Transportation Engineers
NCHRP	National Cooperative Highway Research Program
NCTRP	National Cooperative Transit Research and Development Program
NHTSA	National Highway Traffic Safety Administration
SAE	Society of Automotive Engineers
TCRP	Transit Cooperative Research Program
TRB	Transportation Research Board
U.S.DOT	United States Department of Transportation

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INTRODUCTION

GUIDEBOOK PURPOSE

Much has been written about performance measurement in the transit industry. Many performance indicators and measures have been developed and used in a variety of ways in response to differing transit agency goals and objectives.

What has been lacking in the transit industry is a rigorous process for determining the most appropriate performance measures and indicators that should be used by a transit organization. In addition, traditional cost-efficiency indicators (e.g., operating expense per vehicle revenue mile and/or hour) and cost-effectiveness indicators (e.g., operating expense per passenger mile and/or passenger trip) are sometimes not linked to customer-oriented and community issues.

This Guidebook is intended to assist transit system managers in developing a performance-measurement system that uses traditional and non-traditional measures to address customer-oriented and community issues. It will also be useful to metropolitan planning organizations that desire to add transit-focused performance measures to their planning efforts.

HOW TO USE THIS GUIDEBOOK

The Guidebook's chapters provide information appropriate to individual steps in the process of developing a transit performance-measurement program, ranging from identifying the need for a program to making use of a program's results. Consequently, it is not necessary to read the entire Guidebook at one time to make use of it.

GUIDEBOOK ORGANIZATION

Measuring performance.

Chapter 2 discusses why an agency would want to develop a performance-measurement program and the potential benefits from such a program. It includes information on the different points of view that transit performance measures can reflect, discusses the importance of customer satisfaction, describes the characteristics of an effective performance-measurement system, and shows how performance measures are used by service industries in the private sector.

Case studies.

Chapter 3 contains twelve examples of successful performance-measure programs. Six of these case studies look at the overall programs of different-sized fixed-route and demand-responsive agencies. The other six case studies look in more detail at specific aspects of certain performance-measurement programs that are particularly notable.

Developing a program.

Chapter 4 provides an eight-step process for implementing or updating a performance-measurement program. Each step provides a list of agency "things to do" before continuing on to the next step, describes how to do those things, and provides examples of different approaches used by transit agencies in accomplishing that step. This chapter also provides information specific to ADA complementary paratransit systems, general demand-responsive systems, rural systems, and contracted services. The chapter concludes with recommended core performance measures and an example of how an agency could use this Guidebook to develop a performance-measurement program.

Performance-measurement tools.

Chapter 5 provides resources for agencies in the process of developing a performance-measurement program. This chapter covers categories of performance measures that agencies may wish to consider, different types of measures that can be used, data sources and data collection techniques, data management, performance standards, and performance reports.

Performance measure selection menus.

More than half of this Guidebook consists of detailed summaries of more than 400 performance measures used in the transit industry. To help agencies quickly find measures appropriate to their goals, objectives, and resources, Chapter 6 provides a series of selection menus that guides users through a series of questions that lead to specific measures or families of measures.

Finally, two appendices provide overviews of customer satisfaction surveys and passenger environment surveys.

GUIDEBOOK MEDIA

This Guidebook is provided in two forms: a printed document and an electronic version available on the accompanying CD-ROM. The printed version will be useful to those who want to read the material one chapter at a time to gain a basic understanding of transit performance measurement. The electronic version will be useful to those who are already familiar with transit performance measurement and who want to find specific items of interest quickly. The electronic version is extensively hyperlinked, allowing users to jump immediately to related material and to navigate the performance measure selection menus in Chapter 6. The references section contains a number of links to other related documents available on the Internet at the time the Guidebook was published.

Internet links are subject to change.

Links to material on the Internet were checked at the time the Guidebook was developed, but are subject to change as web sites are reorganized. If a link appears broken, try the basic site (e.g., http://www.examplesite.com), and then navigate through the site to find the document.

BACKGROUND DOCUMENT

A *Transit Performance Measurement Background Document* is available in electronic format on the CD-ROM. This report provides 21 additional case studies not included in this Guidebook, an annotated bibliography of nearly 200 documents relating to transit performance measurement, and other relevant material used to develop this Guidebook. Some hyperlinks in the electronic version of the Guidebook will jump to relevant sections of the Background Document. For this feature to work properly, users should ensure the electronic Guidebook and Background Document are either (1) located in the same directory on their computers or (2) are being viewed from the CD-ROM.

OTHER REFERENCE MATERIAL ON THE CD-ROM

The CD also contains related TCRP documents and useful software.

The CD-ROM also contains (1) a library of related TCRP documents on performance measurement and (2) software developed for the Florida Department of Transportation that assists in analyzing National Transit Database data and helps identify and compare peer agencies. A "Read Me" text file on the CD-ROM lists all of the files included.

TYPOGRAPHIC CONVENTIONS

The following conventions are used in this Guidebook:

- *Italic* text is used for individual performance measure names, document names, and headings in bulleted lists.
- Margin notes are used to highlight certain points and to facilitate finding specific topics within a particular section.

Margin notes look like this.

- **Boxed bold text is used in Chapter 4 to highlight the most important things to consider at each stage of developing a performance-measurement program.**
- Blue underlined text indicates hyperlinks in the electronic version of the Guidebook.
- References are indicated by bold, italic numbers in parentheses (***1***). Clicking on these numbers in the electronic version of the Guidebook takes the user to the appropriate reference. Once there, clicking on the hyperlink provided below the reference (if available) will open a copy of that document, assuming that the document's location on the Internet has not been moved.
- The slash mark "/" is used in performance measure names to indicate alternative forms of the measure. For instance, "road calls per bus/bus model/failure type per month" indicates that the measure can be expressed as *road calls per bus per month, road calls per bus model per month,* or *road calls per failure type per month.* The word "per" is always spelled out in measure names and the slash is not used as a substitute for "per" in those names. The slash mark is used to indicate "per" in measurement units (e.g., km/h).

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MEASURING PERFORMANCE

WHY MEASURE PERFORMANCE?

Performance measures are used by transit agencies for three main reasons:

1. Because they are required to do so;
2. Because it is useful to the agency to do so; and
3. Because others outside the agency need to know what is going on.

Performance measurement for reporting purposes.

Reporting and regulatory requirements will dictate a certain number of performance measures that will have to be reported. The measures that agencies are required to collect and report to the National Transit Database (***1***) are an example.

Performance measurement for self-improvement.

Agencies collect other measures to help identify how well service is being provided to their customers, the areas where improvement may be needed, and the effects of actions previously taken to improve performance. In these cases, agencies use performance measures to help provide service as efficiently as possible, monitor whether agency and community goals are being met, and—over time—improve service so that it attracts new riders. Changes in policy, procedures, and planning can result from an understanding and appraisal of certain measures.

Performance measurement for communicating results.

Finally, decision-making bodies, such as transit boards and funding bodies, need to have access to accurate information to help them make decisions on where and when service should be provided and to support actions designed to improve performance. The public is also interested in knowing how well service is being provided and may need convincing that transit provides a valuable service, for them, for someone they know, or for the community as a whole.

Performance measurement data provide transit agency management with objective assessments of current circumstances, past trends, existing concerns, and unmet needs. Key management uses of a performance measurement system include

- Service monitoring,
- Evaluation of economic performance,
- Management functions,
- Internal communications,
- Development of service design standards,
- Communication of achievements and challenges, and
- Noting of community benefits.

Performance measure uses will be discussed in greater detail later in this chapter. However, as a whole, performance measures are used because they can provide perspective, understanding, and context to what has gone on and what is going on within an organization. Large amounts of data are often available that can easily overwhelm someone attempting to understand the role of transit within the community. A structured performance-measurement system can help agencies select and distill key data items in order to better understand how things are working and to more readily identify areas needing improvement.

PERFORMANCE POINTS OF VIEW

The old adage "where you stand depends upon where you sit" is certainly applicable with respect to which performance measures are the most valuable. What is important and vital in the performance and delivery of transit service depends significantly upon perspective. Four different perspectives—customer, community, agency, and vehicle/driver—are discussed below. Figure 1 identifies areas of interest to each of these groups, and examples of performance measures in each of those areas.

CUSTOMER

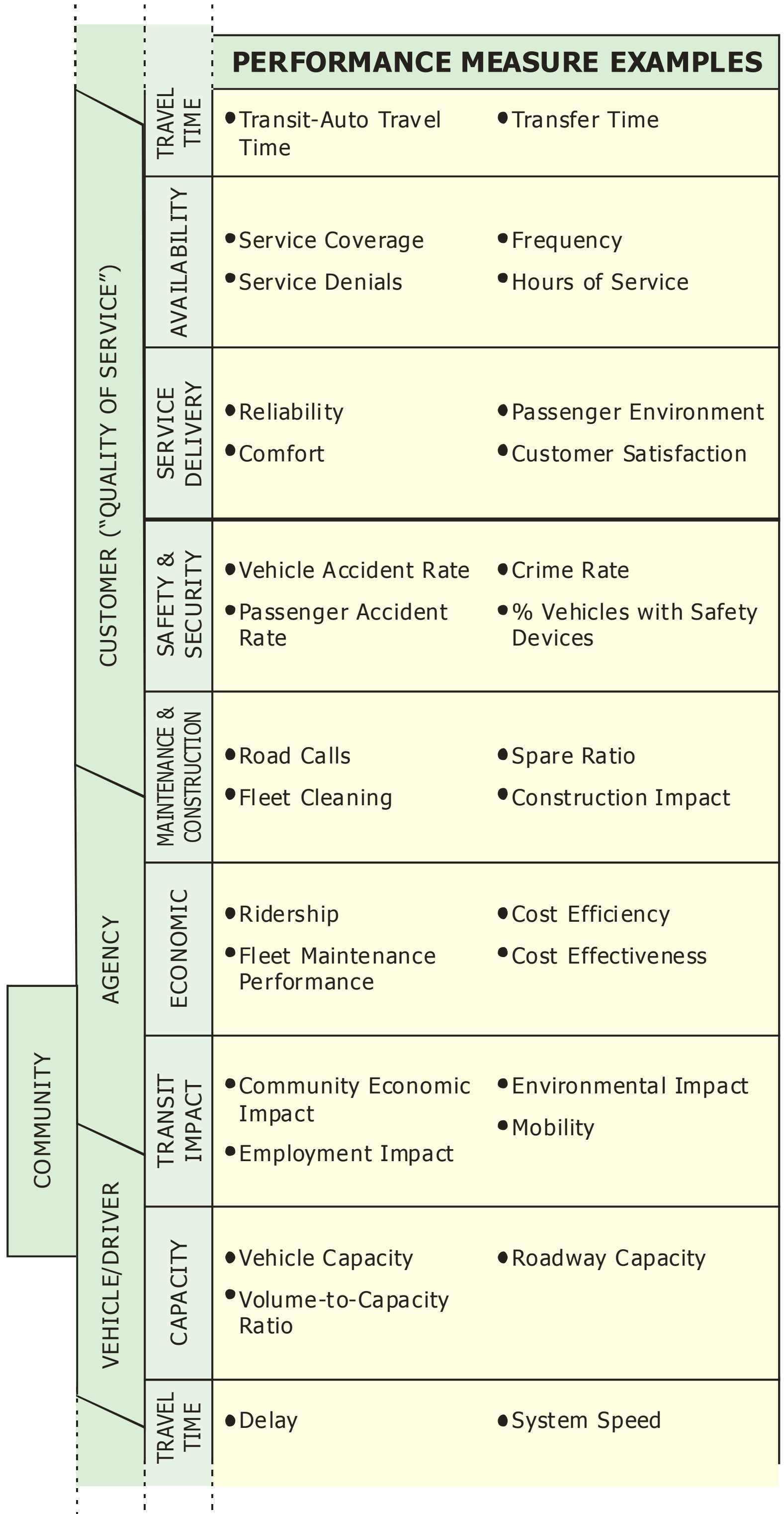
The *Transit Capacity and Quality of Service Manual* (**2**) identifies two areas of greatest concern to passengers: service availability, and the comfort and convenience of service when it is available.

Transit availability.

Transit service is an option for a trip only when service is available at or near the locations and at times when a customer wants to travel, can get to and from the transit stops, knows how to use the service, and sufficient capacity is available at the desired time. If any of these factors is not satisfied, transit will not be an option for that trip—either a different mode will be used, the trip will be taken at a less convenient time, or the trip will not be made at all.

These factors can be summarized as

- *Spatial availability:* Where is service provided, and can one get to it?
- *Temporal availability:* When is service provided?
- *Information availability:* Does the customer know how to use the service?
- *Capacity availability:* Is passenger space available for the desired trip?



Travel time overlaps the vehicle/driver and customer points of view.

Figure 1. Transit Performance Measure Points of View, Categories, and Examples

Transit comfort and convenience.

If service is available for a given trip, a customer may choose transit if its comfort and convenience are competitive with other available modes. Things fully or partially under the control of the transit agency that affect this decision are

- *Service delivery:* How well is an agency delivering the service it promises on a day-to-day basis, and how well is it meeting customers' expectations? Factors include the reliability of service, the quality of customer contacts with agency staff, passengers' physical comfort while using transit, and the achievement of promised service goals.
- *Travel time:* How long does it take to make a trip by transit, particularly in comparison to other modes? Results can be reported by themselves, aggregated by the number of people (e.g., person-minutes of delay), or converted to a monetary value.
- *Safety and security:* What are passengers' perceptions, as well as the realities, of the risks of being injured (*safety*) or becoming the victim of a crime (*security*) while using transit?
- *Maintenance:* Certain aspects of an agency's maintenance program affect passengers' perceptions of service quality. A vehicle's breaking down while in service impacts passengers' travel time for that trip and their overall sense of system reliability. Having insufficient spare buses available may mean that some trips are not made; dirty buses may suggest to passengers a lack of attention to less-visible aspects of transit service, while window etchings may suggest a lack of security.

COMMUNITY

Transit service benefits the community as a whole, in such areas as

- Provision of transportation to persons without ready access to a private automobile, including seniors and persons with disabilities,
- Reduction of air pollution,
- Travel when an automobile is not available,
- Parking congestion mitigation,
- Reduction of traffic congestion, and
- Job accessibility for those who are economically disadvantaged.

Community residents will also be concerned with costs and negative aspects of transit service. Examples of these concerns include

- The amount of taxes directly or indirectly paid for transit service,
- The visual attractiveness or unattractiveness of public facilities,
- Loud noise or diesel fumes from buses,
- The perception of waste or inefficiency of bus service, and
- Empty buses.

A community will normally want a transit service that works well at providing service and community benefits and is operated efficiently and effectively. A transit agency can experience greater success in developing community support if it can document its success and identify and address some of the negative concerns associated with performance.

AGENCY

The organization or agency will have a decidedly different perspective. Ensuring that the agency is operating efficiently (i.e., doing things right) and effectively (i.e., doing the right thing) will be central considerations. Individuals within the agency will normally be committed to the success of the mission of transit, which is to provide service and be an asset to the community.

The agency will be most concerned with organizational performance. This includes measures of how well the service is working. Results of performance measures give the agency some guidance as to what course of action to take and what kind of results should occur.

The agency will also be concerned that customer and community concerns are addressed. Many transit operators have assumed that if they did their job well and the performance measures were good, there would be no other customer or community concerns. Others recognize that customer and community concerns are significant issues, but are uncertain as to how to apply performance measures as a means to address those concerns.

VEHICLE/DRIVER

About 60% of U.S. transit trips are made on buses or demand-responsive vehicles (***1***) and more than 99% of the mileage on those trips occurs in mixed-traffic operations (**2**). As a result, the interactions of automobiles with buses play an important role in determining how well bus service can be provided. Increasing traffic congestion can result in longer travel times, less reliable service, and potentially increased costs to agencies. Similarly, actions taken to make transit service faster and more reliable, such as bus signal priority measures, may impact the quality of service of automobile drivers and passengers. Consequently, vehicle-oriented measures are needed to quantify the impacts of autos and transit on each other.

Vehicle-oriented measures include those routinely used by traffic engineers, such as those given in the *Highway Capacity Manual 2000* (**3**). Care must be taken when using these measures, as all vehicles are treated equally, regardless of the number of passengers in each vehicle. For example, while a single-occupant vehicle and a bus carrying 40 passengers may experience the same amount of delay due to traffic congestion and traffic signal delays, the person-delay experienced by the bus is 40 times as great as the single-occupant vehicle (**2**).

IMPORTANCE OF CUSTOMER SATISFACTION

Customer satisfaction is important to transit customers, welfare-to-work clients and other special population groups, employers, the community, transit agencies, and transit employees.

Transit customers who have a pleasant experience while using transit will likely continue to use transit. Choice customers with easily available alternatives are likely to have higher expectations of satisfaction. Even so-called "captive" or "transit-dependent" riders will explore other travel options if their transit experience is sufficiently negative. Building ridership and market share are key objectives of most transit agencies and can be influenced by improving customer satisfaction. Transit may improve captive customers' overall quality of life if it removes an actual or perceived barrier for them.

For welfare-to-work clients and other special population groups, transit may be the difference between holding a job and no job. Access to jobs provides enhanced self-esteem, the ability to live independently, and the ability to support a family. These benefits appear to be intangible because they are difficult to price. However, these benefits are very tangible to each life that is affected by transit.

For employers, transit users will likely be more productive workers if their commuting stress is diminished. Furthermore, an extremely poor commute could actually encourage absenteeism by discouraging workers from going to work. Consequently, for employers, a low level of customer satisfaction may mean a decreased pool of potential workers from which to choose.

For employees, transit needs to be reliable, comfortable, and convenient. Buses that run late or early can cause serious commuting and workplace difficulties. Getting to work on time and getting home promptly are important to employees. Transit vehicles need to be comfortable, and the trip needs to take place in as safe an environment as possible.

For the community, satisfied customers may result in an increased group of transit users within the community, who may be more receptive to increased funding for transit services.

For transit agencies, higher levels of customer satisfaction are associated with a better public image, customer loyalty and, consequently, customer retention and increased ridership, all else being equal. Transit customers experiencing high levels of satisfaction will be more likely to encourage their friends and relatives to take transit. Although empirical evidence is limited, increases in customer satisfaction are generally believed to (***4***, ***5***)

- Shift the demand curve upward and/or make the slope of the curve steeper (i.e., lower price elasticity, higher margins),
- Reduce marketing costs (customer acquisition requires more effort),
- Reduce customer turnover,

- Lower employee turnover (satisfied customers affect the satisfaction of front-line personnel),
- Enhance reputation and public image (positive customer word-of-mouth), and
- Reduce failure costs (handling customer complaints).

One source that does provide evidence of these linkages is *TCRP Web Document 12* (**6**), which reports results of studies that associate changes in service and other components of customer satisfaction with ridership levels. These studies are not always conclusive, and it is often difficult to isolate the effects of service and service quality changes on ridership, due to the confounding effects of demographics, environmental variables, and economic conditions. However, many studies have indicated that service improvements result in increased demand. If the improvements are accompanied by favorable demographics and economic growth, ridership growth can be significant.

CHARACTERISTICS OF AN EFFECTIVE PERFORMANCE-MEASUREMENT SYSTEM

Nakanishi and List (**7**) identified a number of key characteristics of effective performance-measurement systems. Included among the key characteristics are

- Stakeholder acceptance,
- Linkage to agency and community goals,
- Clarity,
- Reliability and credibility,
- Variety of measures,
- Number of measures,
- Level of detail,
- Flexibility,
- Realism of goals and targets,
- Timeliness, and
- Integration into agency decision-making.

The following sections describe the characteristics of effective performance-measurement systems in more detail.

STAKEHOLDER ACCEPTANCE

Several key groups of stakeholders must accept the performance-measurement program for the program to have long-term viability and usefulness. Experience shows that a program initiated without broad input and support of stakeholders is likely to fail or, at a minimum, operate substantially below expectations.

Transit agency management is the first key group of stakeholders. Ideally, senior management should not only agree to the performance-measurement system, but also take the lead in its development and promotion. Management controls the resources devoted to measuring and reporting performance; lack of management support will make it difficult, if not impossible, to adequately measure performance. Furthermore, policy and operational changes designed to improve performance will not occur without management support.

Agency management should take the lead.

The second group consists of transit agency managers and operational employees. Because performance measures reflect the interests of a wide range of individuals, broad input into the development of the measures is valuable. If agency employees have a chance to participate in the development of the performance-measurement system, they will be more willing to accept the program, be more attuned to results, and be more motivated to achieve the agency's goals. Brown (***8***) states that employee and manager acceptance is particularly important when pay incentives are linked to performance measures.

Agency staff.

Transit agency customers, including potential customers, are the third group of stakeholders. A performance-measurement program should address the aspects of transit service that are important to customers. Customers will measure results based upon their experiences as reflected by these data, so it is important that the performance measures be viewed as accurate and realistic gauges of what is occurring. Different measures may be required for different types of customers, as expectations may vary by mode, route, or location (***9***).

Transit agency customers.

Another group of stakeholders is the agency's governing body. All of the agencies interviewed for this project stated that some aspect of performance-measurement statistics is reported to their transit board, board of trustees, city council, or similar body. Performance measures are viewed as an essential objective assessment that will aid the governing body in making policy and financial decisions. The use of performance measures can also allow policy-makers to show their constituents that the transit agency performance is addressing community needs.

Agency governing body.

If performance measures are being used to evaluate the performance of a service contractor, whether or not financial incentives are included as part of the contract, a fifth group that clearly needs to be involved is the contractor. Performance measures should encourage the contractor to operate in a manner that will advance an agency's key goals and improve performance, while limiting or penalizing a contractor for negative outcomes. Contractor acceptance of performance measures is normally tied to the ability of the contractor to significantly influence their outcomes. If outcomes of a specific performance measure are largely outside of a contractor's control, acceptance of that incentive or penalty is less likely.

Service contractors.

Linkage to Goals

A transit agency's goals should reflect the most important aspects of what it wishes to accomplish. Performance measures are the primary means of assessing how successful an agency is in accomplishing its goals. CalTrans (***10***) summed this up well when it said that the purpose of performance measures is "to tell us where we are in terms of where we want to go." Changes in performance in terms of accomplishing established goals should be reflected by the chosen measures.

When developing a performance measure, it should be clear what goal(s) the measure will help achieve. If a performance measure cannot effectively be tied to a goal, then it is necessary to either reassess the value of that performance measure or to reassess the transit agency's key goals with regard to relevance.

Barnum and Gleason (***11***) use the example of *cost per passenger* in demonstrating how a measure may or may not be effective in measuring goal accomplishment. They state that a low cost per passenger ratio is traditionally assumed to indicate an effective system. However, a high-cost system that moves a high volume of passengers will have a higher ratio than a cheaper system that carries fewer passengers. If the system's goal were to move as many people as possible, the first system would be more "effective" at achieving this, even though it has a higher value for this ratio. The authors conclude that measures alone do not communicate meanings such as "effective" or "efficient," which are relative terms that are given meaning by a system's objectives.

Clarity

The program's intended audience should understand the performance measures used in the program. Governing bodies and customers need to understand how and why a specific performance measure is relevant and significant to the successful operation of the transit agency. However, acceptance of measures by stakeholders at all levels will be facilitated if the measures are easy to understand and the links between measures and goals are evident. Measures based on complex formulas or data that cannot be easily explained will often be met with befuddlement and bewilderment rather than acceptance. Brown (***8***) suggests that visually appealing presentation methods, such as graphs that succinctly convey performance results, are important for communicating results to decision-makers and the public. CalTrans (***10***) also identifies this in their stated need for "routine, readable reports."

Reliability and Credibility

The reliability of performance-measure results directly depends on the quality of the data used to calculate the measures. Some kinds of data normally are more accurate than others. Fielding (***12***), for example, states that financial data are the most reliable, while passenger miles are the least reliable. The reliability of measures derived from manual data collection efforts depends on the amount of training the data collectors receive, and the amount of time they devote to collecting data. The Capital District Transportation Authority in Albany, New York, needed to train its bus operators to use and record farebox information correctly before it could generate reliable performance measures based on farebox data. Automated data collection systems are not necessarily error-free, either, as the parameters used to define a particular data value (e.g., departure time from a bus stop) may not be consistent with how an agency intends to use the data as part of a performance measure. The methodology used to calculate a performance measure should be consistent between reporting periods, so that accurate comparisons can be made between different periods of time.

Objectivity is another aspect of reliability. Those involved in developing measures, obtaining data, and analyzing performance should not permit their self-interests to affect the accuracy of the results. Performance measures should not be selected on the basis of which measures will make the agency look good and avoided where those performance measures make an agency look bad. Rather, selection of performance measures should be based on how accurately and fairly those measures assess agency performance and whether they can be used as a tool to measure goal achievement.

Measures selected merely to make an agency look good are of little help in identifying areas for improvement.

VARIETY OF MEASURES

The performance measures used by a given transit agency should reflect a broad range of relevant issues. For a variety of reasons—particularly federal reporting requirements and the relative ease of obtaining data—many agencies have focused on measures reflecting financial performance and ridership. Critical aspects of performance that are important to customers and the community at large are often insufficiently addressed.

Performance measures are also needed to assess past, present, and future performance. Some measures present data for trend analysis—for example, the average number of transit riders per month for the last six months, while other measures describe what is currently happening—for example, the number of riders for the current month. Still others serve as predictors or indicators that something may be going wrong—for example, data that report a decrease in rider satisfaction may forewarn a future decline in ridership.

Linkages between measures addressing a broad range of issues and those addressing different timeframes are also valuable. Kaplan and Norton (***13***) note that financial measures express past performance, while measures of customer satisfaction and organization innovation drive future performance. Schiemann and Lingle (***14***) identify the need for both quantitative and qualitative measures. In this context, quantitative measures involve things that can be measured without interpretation (e.g., a count of the number of complaints received about late buses over the course of a month), while qualitative measures assess how customers perceive the service that is provided. These measures may be measured quantitatively (e.g., a customer rating of bus reliability on a 1-to-5 scale), but each surveyed individual's ratings will be based on that customer's experiences and expectations, rather than some objective definition.

Number of Measures

The need for a variety of measures must be balanced to avoid overwhelming the end user with superfluous data to sift through to find the key drivers of service quality. Brown (***8***) describes this as choosing between "the vital few measures and the trivial many" and suggests an upper limit of 20 measures that any level within an organization should try to track. Schiemann and Lingle (***14***) describe one business that tried to track 150 measures, resulting in a "plethora of unfocused, misdirected activities," due to individual managers each trying to optimize a different subset of measures, with no two managers having the same set of priorities. The benefit of adding an additional measure should clearly outweigh the effort to measure it (***8***). Indexes that combine several measures into a single measure can be used to reduce the number of measures reported. However, the danger is that indexes that combine several measures can mask important trends in the component measures (***8***).

Level of Detail

Measures used within a performance-measurement program should be sufficiently detailed to allow accurate identification of areas where goals are not being achieved, but should not be more complex than needed to accomplish this task. Different levels of detail may be required at different organizational levels. An overall measure of system on-time performance might be reported to the transit board, for example, but operations, scheduling, and maintenance departments might track their own, more detailed, performance measures that relate to their department's influence on overall on-time performance. The important thing is that lower-level measures should be consistent with higher-level measures (***8***).

Available financial and information-gathering resources may constrain the level of detail needed for evaluation of statistics. Cambridge Systematics (***15***) recommends that agencies first identify ideal measures that match their goals at the desired level of detail, and then, if needed, identify surrogate measures that can be used until such time as the ideal measures can be identified.

Flexibility

Goals change over time, as do external factors. A performance-measurement program should provide the flexibility needed to permit change in the future, while retaining links to necessary historical measures.

REALISM OF GOALS AND TARGETS

Targets should be realistic, but slightly out of reach, to encourage managers and employees to find ways to continually improve performance. Unrealistic targets will cause the program's credibility to be questioned, if no reasonable amount of effort can raise performance to the target level, and particularly if external factors not under an agency's control have a substantial impact on a measure's results. Customer surveys can be used to match customer perceptions to existing performance, to help determine whether the targets being used or considered are consistent with passenger expectations.

TIMELINESS

Timely reporting allows all to understand the benefits that resulted from actions to improve service and also allows agencies to quickly identify and react to problem areas. One agency staff member responsible for performance reporting noted that "executive management lives and breathes by the reports," and that if for some reason a report is late, managers contact his department to inquire about it. He also indicated that two obstacles that had to be overcome in developing his agency's program were (1) certain departments' "ownership" of data, and their reluctance to share it, and (2) that not everyone received the same reports at the same time under previous programs. Automating some aspects of data collection may help to develop more timely reports—the Chicago Transit Authority was looking forward to automating some of its data collection efforts for this reason.

INTEGRATION INTO AGENCY DECISION-MAKING

In order for the effort put into developing and monitoring a performance-measurement program to be worthwhile, agencies must carefully consider what the performance results are indicating, and use the results both to evaluate the success of past efforts and to help develop ideas for improving future performance. Specific actions should not be mandated as a result of a particular performance measure result; rather, measures should be used to flag under- or over-achieving segments, with specific actions determined by management on a case-by-case basis, depending on the individual circumstances.

PERFORMANCE MEASURES IN PRIVATE INDUSTRY

As a service industry, transit must understand and work to satisfy the needs of its customers, including current passengers, potential passengers, and the community at large. This next section examines how other service industries have implemented customer-focused performance-measurement programs and describes the lessons that transit agencies can learn from those experiences.

PRIVATE INDUSTRY PERFORMANCE MEASURE CATEGORIES

When discussing performance measures with private industry representatives, measures are most often structured into three categories: revenue and cost measures, system and change monitoring, and customer satisfaction and loyalty measures. Examples of these three types of performance measures, taken from both private industry and transit, are shown in Table 1.

Table 1. Categories of Private Industry Performance Measures

Category	Examples
Revenue and cost measures	Gross profit margin, net income, percent of revenue from fare box, cost per rider/mile/trip
System and change monitoring	Secondary data measures such as inventory on hand, number of complaints, accidents per mile, number of vehicle washings
Customer satisfaction/loyalty	Does service meet customers' expectations? Will customers recommend service or continue to re-purchase or use service?

Until the 1980s, transit agencies and private industries both emphasized the first two categories of performance measurement. In fact, until recently, the third category of customer satisfaction and loyalty measurement was really only a subcategory of system monitoring—one among many indicators to track.

Changes came first in the automobile industry. For example, Chrysler built the K cars that met internal system performance measures. The problem was that customers did not like them. The countering "pull-factor" on customers was the introduction of products by brands such as Toyota and Honda, which had improved quality, but at a comparable price point. This improved quality included factors such as longevity, which generated higher re-sale values. This focus on quality completely changed the overall value equation by increasing customer expectations for all brands, forcing competitors, mostly domestic, to adopt new initiatives to improve these same factors or risk losing the very customers they considered their core. General Motors, for instance, had a U.S. market share approaching 60% before these products entered the market in sufficient numbers. Today GM struggles to maintain a 30% share.

While many of yesterday's private-sector consumers were loyal to a specific brand, loyalty to brands in the new paradigm in many cases has weakened. Manufacturers in other domestic industries have taken note. Today, consumers require manufacturers to not only provide comparable levels of quality and product satisfaction but also to go beyond this and provide additional reasons for maintaining them as a loyal customer. Some manufacturers refer to this as "delighting the customer." As other industries learned from this, they searched for ways to measure not only the traditional things-gone-wrong (TGW) or satisfaction levels, but also for ways to add extra visible levels of service or features. These industries then tracked these added elements to determine whether they truly differentiated themselves from their competitors.

Among service industries, a corresponding trend had an added effect. Starting in the 1990s, customer complaints increased dramatically. There are various reasons for this. Either the level of service declined (perhaps with an overload of customers), customer expectations for service rose, or customers became more vocal about their complaints. In the health care industry, as in passenger air service later on, the government took note. The National Quality Council mandated annual customer satisfaction surveys and the posting of results for managed health care agencies. Also, the Council initiated the American Customer Satisfaction Index. This annual survey tracks customer satisfaction with over 200 American businesses and organizations.

http://www.theacsi.org/

With the private sector's accelerated emphasis on listening to "the voice of the customer," customer satisfaction and loyalty measurement came into its own as a performance measure category, at times, replacing existing system- and change-monitoring measures as the better means of judging the system's condition.

In the latest cycle of development among private industries, customer satisfaction and loyalty measures are being linked with revenue and profitability measures. The former is considered an indicator of the latter. This is evident in a year 2000 statement, reporting "it takes five times the costs to attract a new customer as to retain an existing customer."

Attracting new customers is much more expensive than retaining existing ones.

While customer satisfaction measurement at transit agencies has increased over the past five years, particularly at a number of metropolitan and suburban systems, it has not often replaced the second category of system performance and change monitoring. For the most part, among transit agencies, customer satisfaction and loyalty measurement remains a "softer community measure," but one of a host of other system (secondary) measures. Some transit systems serve and count trips, rather than customers' opinions. Moreover, there have been few attempts to link revenue and profitability measures with customer satisfaction measures. (A notable exception is the recent research effort at the Chicago Transit Authority to link increases in the customer loyalty index with increases in "choice" riders (***16***).)

There are numerous reasons customer satisfaction and loyalty measurements have not taken hold as quickly in the transit industry as in the private sector. Transit agencies often have differences in goals and objectives. Agencies also are limited in the extent to which they can regard customer satisfaction and loyalty measurement as a full-fledged performance measure category. These reasons are

- Transit agencies are not wholly profit-oriented or revenue-driven.
- There is a "built-in" need to report system performance measures to agency, government, and community boards.

- Financial resources are limited. To make their impact timely, customer satisfaction and loyalty measurement often requires outside consultants and updated technology for maintaining customer databases and electronically transmitting reports.
- There are differences in customer satisfaction and loyalty between transit-dependent ("non-choice") riders and "choice" riders.

Only a handful of metropolitan and suburban transit agencies have the resources to conduct large-scale market research and customer satisfaction tracking studies on an ongoing basis. Specifically, transit agencies generally lack up-to-date electronic databases of their customers, making it difficult or impossible to utilize efficient and modern telephone and web-based research methods. Transit agencies also often lack intranet systems or other company-wide web-based electronic means for distributing the results of customer research to all employees in a timely manner. Likewise, critical problem incidences gleaned from customer surveys cannot be conveyed electronically to transit agency front-line personnel for immediate resolution.

One of the most important learning experiences from private industry customer satisfaction and loyalty performance programs is that these efforts require extensive "buy-in" from the highest levels of an organization's management and the involvement of all departments as well as front-line personnel. More successful programs link improvements in customer satisfaction and loyalty measures to personnel compensation and/or bonus plans—when a validated link can be made between satisfaction levels and profitability.

CUSTOMER SATISFACTION MEASURES USED IN PRIVATE INDUSTRY

Specific customer satisfaction and loyalty performance measures used in private service industries that can be applied to transit industry market research are listed below. These measures and service attributes are rated from the customer's perspective:

- Overall customer satisfaction with service (on a 7- or 10-point scale);
- Meeting customer expectations ("Did the service exceed your expectations, meet your expectations, almost meet your expectations, or fail to meet your expectations overall?");
- Customer loyalty measures ("How likely are you to recommend this transit service to others?" and "How likely are you to (ride) (keep riding) this transit service?");
- Number and nature of critical incident reports (compiled from client survey verbatim);
- Service attributes regarding personnel interactions:
  - courtesy,
  - timeliness of providing service,
  - quality of information and assistance, and
  - resolution of problems that arise without unnecessary delay;

- Service attributes regarding service efficiency;
- Service attributes regarding environment;
- Service attributes regarding security and safety;
- Service attributes regarding information about the service;
- Service attributes about comfort and convenience of use; and
- Value of the service for fare paid.

IMPLEMENTATION OF PRIVATE INDUSTRY PERFORMANCE-MEASUREMENT PROGRAMS

Within the private sector, evolving emphasis on the customer satisfaction performance-measurement category has been augmented by increased emphasis on the development of quality processes. The process paradigm was introduced, first in Japan and then in the United States, by quality expert W. Edwards Deming (1900-1993). Deming was first ignored in the United States. However, the Japanese took a deep interest in his management methods, which eliminate inspection and make quality everyone's job. According to Deming, "Inspection with the aim of finding the bad ones (or bad incidences) and throwing them out is too late, ineffective, costly. Quality comes not from inspection but from improvement of the processes. (***17***)" Deming insisted that managers—not workers—are responsible for quality. If there are problems, the system is to blame.

In the 1980s the quality approaches of Deming and Japanese experts were introduced in the United States at Ford Motor Company and other manufacturing firms. Quality Function Deployment (QFD), as it has been called, is a part of the Total Quality Management movement, with the primary goal of overcoming both disregard for the voice of the customer and the problem of different individuals and functions working toward different requirements. QFD uses teams of personnel from all functions (departments) of the organization, listening to extensive customer qualitative (i.e., focus group) feedback about the minute details of a product or service, then working together to devise processes or product reengineering that improves customer perception. Often, every step of the manufacturing or service process is taken apart and examined by QFD teams in an effort to build what Deming called a "House of Quality," a charting of customer requirements against a corresponding matrix of appropriate product and process features.

In the late 1990s, globalization and increased competition led to institutionalizing the quality process movement, through certification sponsored by the International Organization for Standardization (ISO), known as the 9000 (now ISO 9000:2000) quality management system. Private-sector companies seek this certification because it is increasingly required to conduct business in Europe and Asia. In the U.S., ISO 9000:2000 certification is often a forerunner for consideration for such national recognition as the Malcolm Baldridge Award and for other contracts and awards granted by major corporations and associations. In 2002, over 175 organizations or companies are registered as having met ISO 9000 standards. Like QFD, ISO 9000 emphasizes the continuous development of quality processes.

ISO 9000 certification is based on eight quality management principles to be used by senior management as a framework to guide their organizations toward improved performance. These principles were derived from the collaborative experience and knowledge of international experts who participate in ISO's Technical Committee on Quality Measures and Assurance and who are responsible for developing and maintaining ISO 9000 standards. These principles and a brief description are provided below.

PRINCIPLE 1: CUSTOMER FOCUS

Organizations depend on their customers and therefore should meet customer requirements and strive to exceed customer expectations. This principle leads to measuring customer satisfaction, needs, and expectations—and acting on the results. Its goals are ensuring that the organization's objectives are linked to customer needs and expectations, the systematic management of customer relationships, communication of customer requirements throughout the organization, and a balanced approach to satisfying customer stakeholder groups (primary customers, boards, shareholders, employees, suppliers, and society as a whole).

PRINCIPLE 2: LEADERSHIP

Leaders have the responsibility to establish unity of purpose and to create and maintain an internal environment in which people become fully involved in achieving the organization's objectives. These obligations include ensuring that the needs of all interested parties are considered; establishing a clear vision of the organization's future; setting goals and targets; creating and sustaining shared values relating to fairness, trust, and ethical practices; providing people with the required resources and training; and inspiring, encouraging, and recognizing people's contributions.

PRINCIPLE 3: INVOLVEMENT OF PEOPLE

People at all levels are the essence of an organization and their full involvement enables their abilities to be used for the organization's benefit. All functional levels of the organization must understand their contribution, identify constraints to their performance, accept ownership of their responsibilities, share knowledge and experience, seek opportunities for improvement, and openly discuss problems and issues.

PRINCIPLE 4: PROCESS APPROACH

A desired result is achieved more efficiently when activities and related resources are managed as a process. The activities to obtain a desired result must be systematically defined. Clear accountability and responsibility for managing both activities and interfaces among activities must be established. The focus must be on the factors (e.g., resources, methods, and materials) needed to improve key activities of the organization.

PRINCIPLE 5: SYSTEM APPROACH TO MANAGEMENT

Identifying, understanding, and managing interrelated processes as a system contributes to the organization's effectiveness and efficiency in achieving objectives. The interdependencies between the processes of the system must be understood and structured approaches that harmonize and integrate processes must be developed. Cross-barriers must be reduced.

PRINCIPLE 6: CONTINUAL IMPROVEMENT

Continual improvement of the organization's overall performance should be a permanent objective of the organization. Consistent organization-wide approaches to continuous improvement of the organization's performance must be employed. Measures should be established to track improvements, and successes should be continually acknowledged.

PRINCIPLE 7: FACTUAL APPROACH TO DECISION-MAKING

Effective decision-making is based on the analysis of data and information. Data and information must be sufficiently accurate and accessible to those who need it. Decisions must be made on factual analysis, guided by experienced intuition.

Objective performance measures regularly collected and reported provide accessible, factual information.

PRINCIPLE 8: MUTUALLY BENEFICIAL SUPPLIER RELATIONSHIPS

An organization and its suppliers are interdependent and a mutually beneficial relationship enhances the ability of both to create value. Expertise and resources should be pooled with partners and key suppliers should be identified and selected. Communications should be open and clear with information about future plans shared.

For the ISO 9000:2000 certification process, documentation of full implementation of these eight principles or family of standards is acquired through a final audit by an independent, certified ISO consultant. The full guidelines for the certification process are given in the ISO 9000—Selection and Use Manual. Further information is available at ISO's website.

http://www.iso.ch/iso/en/iso9000-14000/tour/magical.html

In general, with the exception of the lack of a market-based need for quality assurance certification, all of the evolving performance measure experience of private industry companies is relevant to applications within the transit industry. The concern is with transit agencies' insufficient financial and technology resources to pursue, on anything close to a commensurate scale, such performance-related activities as customer satisfaction and expectation research, extensive internal process charting and documentation, implementation of the latest technology and communication networks, and/or use of outside management consulting services.

Performance Measure Uses

Significant effort may be required to develop and maintain a performance-measurement program. However, the benefits to the agency of doing so are also significant. This section outlines some of the valuable uses of performance measurement.

Regulatory Uses

Some performance measures are specifically required by federal reporting requirements (NTD), legislative regulations such as the ADA, and federal grant applications.

National Transit Database (NTD)

The National Transit Database (***1***) requires agencies to provide data in several operating and capital-related areas. From these data arise many measures of internal efficiency and effectiveness, including

- *Passengers per revenue hour,*
- *Passengers per vehicle mile,*
- *Farebox recovery ratio,* and
- *Cost per passenger.*

Measures are reported annually by transit agencies to the Federal Transit Administration (FTA) by service mode (e.g., fixed-route bus, demand-responsive, light rail, and vanpool).

Americans with Disabilities Act (ADA)

The ADA is a civil rights measure that requires public agencies to ensure access to public transportation for persons with disabilities. The ADA requires agencies to develop means to document compliance with the Act.

One example of this is in the area of ADA complementary paratransit. The regulations indicate that capacity constraints including a practice or pattern of *missed trips* are not permissible. Transit agencies need to determine whether missed trips are occurring and, if so, how many are occurring. Reservation and trip data are gathered, and the number and percentage of missed trips are documented. While the percentage of missed trips can be used as a means to measure system reliability, gathering the data is not optional but required to ensure that federal regulations are met.

Grant Applications (Annual)

Performance and operational data are often a significant component of grant applications for state funding. Annual state and federal funding levels are often tied to an agency's level of ridership, population, or service hours.

External Reporting

External reporting involves the development of performance measures that can meet the requirements of agencies external to the transit agency. While the measures may be useful for other purposes, one of their uses is meeting these external requirements.

Municipal Budgeting and Reporting Process

Many transit agencies are part of a city or a county government. Internal processes will require measures of performance that may be either agency-specific (for the transit agency only) or required for all municipal agencies. In either case, performance measures will be required that are not initiated by transit management but by an entity external to the transit agency.

Insurance / Liability

Accident rates and other safety-related measures are used to determine the appropriate level of risk and premiums. If the transit agency is self-insured, past performance is used to develop actuarial estimates of potential liability. Should an external provider be used, performance data will be used to assess the level of agency risk. In either case, the transit agency needs performance measures and data that will allow the assessment of potential risk and liability.

General Agency Uses

Measures can be used in specific operational and organizational ways. Shaping the assessment and approach to different broad organizational issues is also possible.

Evaluate Overall Organizational Performance

Performance goals should allow the organizations' management to determine how effectively and efficiently an organization has performed in attempting to meet its goals. Individuals at all levels of the organization and key external stakeholders can view and assess how the agency is doing.

Evaluate Departmental Performance

Performance measures may be used to measure specific departmental or sub-departmental results or output. Some measures may be relevant to understanding departmental performance, but often the department's performance has little to do with specific measures. In other cases, there are outcomes in which the department's actions can significantly influence the result. Departmental performance incentives and penalties may be possible for these measures. The goal of such incentives and penalties would be to share benefits resulting from improved levels of performance.

EVALUATE INDIVIDUAL PERFORMANCES

Performance measures can also be used to evaluate performance at the individual level. Prior to the use of scheduling software and other automated information technologies, determining individual driver or customer service agent performance required considerable manual record-keeping and record compilation to derive actual performance data.

The use of scheduling software and satellite technology in the form of Mobile Data Terminals (MDT) and Automated Vehicle Location (AVL) equipment provides accurate scheduled and real-time information that can be used to assess operator productivity and on-time performance. Objective evaluations of operator performance are more easily available to provide internal assessments of individuals and areas.

Improved real-time performance data for all traditional modes of transit can allow for more refined ongoing evaluations of route performance and other measures that were often extracted only by a substantial expenditure of resources and effort.

EVALUATE PAST PERFORMANCE

Understanding past performance is important for two primary reasons:

- To evaluate trends, and
- To assess the impact of policy and other organizational changes.

Significant changes in policy or procedures will occur with the goal of improving performance. Evaluation of past performance can be used to gauge the success of changes to policy or procedures. Performance indicators before and after a change are compared to identify the impact of changes made. Of course, other potential variables accounting for the change must be considered as well.

IDENTIFY AGENCY NEEDS

Performance measures can indicate the need for change. Performance measures allow the use of data and measurements versus using anecdotal observations to adjust service levels.

IDENTIFY PASSENGER BENEFITS

Passenger complaints and compliments, regular surveys with performance levels, and other level-of-service indictors are means of identifying passenger needs and how they are met. In a sense, complaints are anecdotal reports of occurrences. As a group, they can identify passenger needs and concerns.

Identify Community Benefits

Agency policies that may result in community benefits relevant to the community or to decision-makers can be identified by performance measures. If a substantial number of welfare-to-work individuals are able to access transit service and get to a job, it is an identifiable benefit to the community. Another example of an identifiable benefit is a reduction in the number of vehicle-miles driven.

Compare Transit Performance with Similar Transit Systems

Transit agencies of similar size that serve areas with similar demographics are agency peers. Selecting peers requires examining a variety of general data to see if a candidate agency is an appropriate peer. In particular, data collection differences between agencies can produce differences that minimize the value of the comparison.

One example of this issue would be why *passengers per revenue mile* is so much higher for Transit Agency "A" than for Transit Agency "B." What if each agency defines revenue miles differently? Transit Agency "A" may count revenue miles when passengers are aboard and Transit Agency "B" may count revenue miles whenever a revenue vehicle is in service. Data collection is far from uniform, so outputs may differ simply because the data are collected differently and not because of any real disparity in performance. Nevertheless, transit agencies can work to discover and account for these differences to provide some comparison of service effectiveness and efficiency.

Predict Future Performance

All performance measures report past or current performance. However, some measures can also suggest the future performance of other indicators. Declining passenger-oriented measures such as on-time performance may foreshadow future declines in customer satisfaction. Increasing levels of failed drug tests may suggest potential safety or worker productivity issues.

Specific Functional Uses

Communications

Performance measures allow an agency to convey to staff, customers, and decision-makers that a specific goal has been successfully achieved. Effective communication will show how achievement of an appropriate level of performance translates into the achievement of an organizational goal.

Public reporting of goals shows that an agency is interested in serving its community and improving its performance. Even when reported performance measures are less than satisfactory, the process still provides the agency the opportunity to acknowledge the identified problem, explain the reason for the less-than-satisfactory outcome, and outline the steps the agency will take to improve its performance in this area in the future.

COMMUNITY BENEFITS

Transit agencies have the opportunity to use performance measures to communicate the value of transit service to the community. Benefits are not always obvious to the community, and successfully providing quantifiable measures can buttress the contention that transit service is a valuable asset to the community.

Providing mobility is one key area of community benefits. Demonstrating the number of people who use transit over the course of a week is one way that benefits can be conveyed through performance measures. The amount of service provided to persons with disabilities to access jobs, dialysis, or medical appointments is another benefit that can be expressed through performance measures.

Reducing traffic congestion and the amount of land used for transportation facilities are other potential areas of significant community benefits. Establishing measures that can quantify the amount of benefit generated by transit service can provide substantive documentation of efforts and results.

SERVICE DESIGN STANDARDS

Appropriately allocating resources for service delivery results in effective and efficient service. Service design standards use a set of performance measures to determine objectively where and how service is to be allocated.

The decision to add new transit service can be based upon guidelines developed based on performance standards. The amount of estimated transit ridership, the number of transit attractors and generators, and the frequency and span of service can all be tied to performance measures.

Existing routes can be evaluated through service design standards. Routes may be required to maintain a designated level of ridership or be subject to reevaluation and possible elimination if they fail to meet performance standards. Routes that substantially exceed performance standards may be expanded in terms of service frequency or span of service.

SERVICE MONITORING

Performance measures can monitor how well service is performing at a specific time. Measures can determine if goals are being met, are not being met, or are being exceeded. Service trends can also be ascertained through performance measures.

Transit agencies implement policies and procedures designed to improve performance. Performance measures allow agencies to determine the effect of the changes through the use of before and after studies. Any before and after study should attempt to account for variables that may have caused the change, so it can be determined that some or all of the performance change resulted from the change in policy or procedure. External environmental changes can be assessed in a similar manner.

Economic Performance

Performance measures are commonly used to assess how well an agency is performing financially. Many of the traditional transit measures included in economic performance are

- *Cost per passenger,*
- *Farebox recovery ratio,*
- *Cost per revenue hour,* and
- *Cost per revenue mile.*

Management

Determining the performance of functional areas other than service delivery can also be determined by performance measures:

- Risk management performance can be determined through a variety of accident and incident measures to compare and assess the level of safety, risk, and potential liability within a transit service.
- Vehicle maintenance can be assessed through performance measurement. If preventive maintenance is inadequate, high levels of unplanned maintenance and vehicle breakdowns will occur. Negative outcomes in vehicle maintenance result in increased costs and disrupted service.
- Employee satisfaction can also be measured (e.g., through employee surveys). Indirect satisfaction measures such as absence and turnover rates can be used to determine the level of and changes in employee satisfaction. Stable and satisfied employees can improve agency productivity and overall performance in a broad range of organizational performance measures.

Ad Hoc versus Regular Performance Measures

Performance measures are calculated from regularly gathered data, with their results disseminated at designated times. However, not all performance measures used by an agency will be permanent.

Often in response to a unique situation or in response to a crisis, a transit agency will develop one-time performance measures. Developed from an internal study, a consultant's report, or some other source, the purpose of the temporary performance measure is usually to diagnose a specific problem or problems and recommend a course of action.

Ad hoc performance measures can be a valuable tool in developing a better understanding of a specific issue or problem. Often the effort required to develop them is great enough that they can be used only on a limited basis. If a temporary measure is deemed to have sufficient value in understanding an agency's operation, then it may become a regular performance measure.

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CASE STUDIES OF SUCCESSFUL PROGRAMS

This section provides case studies of twelve successful agency performance-measurement programs. The first six case studies present examples of programs used in transit agencies of various sizes:

- Livermore, California: small, fixed-route system with ADA service.
- St. Lucie County, Florida: general demand-responsive system.
- Honolulu, Hawaii: large, ADA paratransit system.
- Denver, Colorado: large, multi-modal system.
- New York, New York: comprehensive performance-measurement program used by one of the largest systems in the world.
- Sydney, Australia: large, multi-modal system that uses performance measures that match specific agency goals.

The last six case studies focus on specific aspects of various organizations' performance-measurement programs that agencies may wish to consider:

- Lansing, Michigan: customer satisfaction and loyalty surveying.
- San Diego, California: transit-related measures used by a metropolitan planning organization.
- Baltimore, Maryland: detailed, citywide performance-measurement program.
- European Union: European efforts to identify best practices in evaluating the performance perceived by the customer.
- Busways: performance measurement conducted by a private Australian bus operator.
- Private industry: example of the process used by an electric utility to become ISO 9000:2000 certified.

The Background Document on the accompanying CD-ROM provides an additional 21 case studies of transit agency and private industry programs from around the United States.

Additional transit agency case studies provided in the Background Document on the accompanying CD-ROM are
Albany, NY
Baltimore, MD (MTA)
Champaign-Urbana, IL
Chicago, IL (CTA)
Chicago, IL (RTA)
Columbus, OH
Hong Kong, China
Houston, TX
Los Angeles, CA
Miami, FL
Nashville, TN
Oshkosh, WI
Portland, OR
San Antonio, TX
San Diego, CA (MTDB)
Tampa, FL (paratransit)

LIVERMORE, CALIFORNIA: SMALL SYSTEM

SYSTEM PROFILE

LAVTA, formed in 1986, provides transit service across 40 square miles to the cities of Dublin, Livermore, and Pleasanton and to unincorporated parts of Alameda County. The agency maintains a fleet of 65 buses and 12 demand-responsive vehicles. In 2000, LAVTA provided 1.8 million unlinked bus trips and approximately 36,000 unlinked paratransit trips. LAVTA is governed by a board of directors comprising council members from each city and an Alameda County supervisor.

Agency Name: Livermore Amador Valley Transportation Authority (LAVTA)

Agency Size: Small

Transit Modes: Urban fixed-route bus, ADA demand-responsive service

PROGRAM GOALS AND OBJECTIVES

LAVTA's performance standards were created to reflect system objectives and were based on industry standards that have been progressively revised. As goals were met, standards were raised. LAVTA staff believes that agency standards should mirror agency goals as closely as possible and that safeguards should be taken to minimize the "arbitrariness" of certain standards.

MEASURES, STANDARDS, AND TARGETS

The agency uses a total of nine performance measures, listed below. Its measures are currently only system-wide, but the intent is to develop soon a system profile manual to create route-by-route evaluations. Currently, the agency reports one set of measures for its fixed-route service and another set for its demand-responsive service. The following measures and standards are for fixed-route bus service:

- Farebox recovery standard – 14%
- Productivity standard – 13.0 passengers per hour
- Service efficiency standard – Increase in operating cost shall not exceed increase in CPI for that region
- Service effectiveness standard – 95% on-time performance, 0% of scheduled departures missed and 0% missed trips, 7,000 vehicle miles between road calls
- Safety standards – 50,000-70,000 vehicle miles between traffic accidents, 1 passenger injury per 100,000 passenger boardings, 100% of preventive maintenance inspections completed within 10% of scheduled mileage

DATA COLLECTION PROCEDURE

LAVTA staff collect performance data monthly. They also conduct a boardings and alightings survey for the overall system every "two to three years." LAVTA staff have found that data on boardings and alightings provide the most useful measurements, although farebox retainment and safety standards are also good. Revisions are made to their performance measures on an annual basis, when the Short-Range Transit Plan is updated.

MONITORING AND REPORTING

LAVTA contracts out the provision of its transit service to a private operator. As part of the contract, the private operator must submit monthly reports to LAVTA that include various operating statistics and performance measures. Furthermore, the private operator is subject to various contractual incentive and penalty clauses depending upon whether the target standards were met in each category. If the system repeatedly fails to meet the target value for a particular performance standard, LAVTA staff will investigate the issue to determine why. The results of the staff investigation take the form of a formal explanation to the board to explain why the standard was not met and what actions will be taken to address the issue.

SUCCESSES AND CHALLENGES

LAVTA has had a relatively high level of success with their performance measurement system. The system has been a useful analytical tool for evaluating system-wide performance and service expansion proposals. Future plans intend to extend performance to a route-by-route level of analysis.

TRANSFERABILITY

The concepts of LAVTA's performance-measurement program could be transferred to other transit systems. The use of contractual penalty and incentive clauses tied to system performance is particularly effective for transit systems that contract out service provision. Overall, LAVTA staff thought that, when considering the transferability of performance-measurement programs, "it is vital to compare apples to apples, and oranges to oranges." In other words, a variety of factors influence the successful implementation of a performance-measurement program, such as demographic characteristics, service area environment, and land use patterns, and all of these factors must be considered when developing a performance-measurement program.

ST. LUCIE COUNTY, FLORIDA: GENERAL DEMAND-RESPONSIVE SYSTEM

SYSTEM PROFILE

Agency Name: Community Transit

Agency Size: Small

Transit Modes: General Demand-responsive Service

Saint Lucie County, Florida, is located on the "Treasure Coast" of southeast Florida. According to the 2000 Census, the county population is 192,695, a 28 percent increase since 1990. The total land area of Saint Lucie County is 572 square miles, with a density of 337 persons per square mile. Community Transit is the contracted public transportation provider for the County.

The Council on Aging of Saint Lucie County operates Community Transit under a three-year transportation service agreement issued by Saint Lucie County. Community Transit provides demand-responsive service to the general population on a county-wide basis. Passenger trips are generated by telephone calls from passengers to Community Transit, which dispatches vehicles in response to passenger requests. Passengers are allowed to schedule trips up to two weeks in advance.

Community Transit provided 158,469 trips during fiscal year 2000. Transit ridership has increased by 82 percent since 1996 when 87,000 rides were provided. The sharp increase in demand has placed significant strains on the ability of Community Transit to meet service demand. Rapid growth is expected to continue with a projected 170,000 passengers to be transported in fiscal year 2001 and 187,000 passengers in fiscal year 2002. Only a small portion of Community Transit's demand is for work trips (13 percent).

Program Goals and Objectives

The objective of the performance-measurement program is to measure the ability of Community Transit to meet budgeted goals in terms of cost, hours, productivity, and ridership.

Measures, Standards, and Targets

The measures used are

- Total annual ridership,
- Passengers per mile,
- Passengers per hour,
- Subsidy of cost per passenger,
- Cost per vehicle hour,
- Cost per vehicle mile,
- Passenger complaints,
- Percentage of no-shows,
- Per capita cost of service,
- Operating expense,
- Miles between safety incidents,
- Passenger trips per employee,
- Average fare,
- Average age of fleet,
- Trips per vehicle, and
- Cost per trip.

Specific goals for the performance measures include the following:

- Annual ridership—goal is based on budgeted service increases,
- Passengers per mile—maintain existing level (or improve),
- Passengers per hour—maintain existing level (or improve),
- Subsidy of cost per passenger—maintain existing level (or improve),
- Cost per vehicle hour—maintain existing level (or improve),
- Cost per vehicle mile—maintain existing level (or improve), and
- Cost per trip—maintain existing level (or improve).

MONITORING AND REPORTING

Data are gathered and compiled into monthly reports. Measures are also compiled in the Annual Operating Report distributed to (1) the Board of Directors of the Council on Aging and (2) the Metropolitan Planning Organization of Saint Lucie County which uses the information for their Transit Development Plan.

SUCCESSES AND CHALLENGES

A success of the performance-measurement program is maintaining the cost per trip for demand-responsive service under $10 per trip for five years. A challenge is that computer software is not adequate for measuring actual data and scheduled data, since trips are currently scheduled manually.

Community Transit has operated as a general demand-responsive service and has provided curb-to-curb service to all its patrons. Therefore, it was not required to comply with the regulations with respect to ADA paratransit. Effective June 1, 2002, Community Transit (under a Florida Department of Transportation grant in cooperation with Community Coach in Martin County) will provide fixed-route service along U.S. Highway 1 in Saint Lucie and Martin County. ADA complementary paratransit service will hence also be provided along the U.S. Highway 1 corridor.

Fixed-route service is seen as a more effective way of meeting growing demand in a more cost-effective manner. Additional routes are planned, but the success of the fixed-route service on U.S. Highway 1 is essential. Two key performance measures currently used by Community Transit for demand-responsive service will need to be measured differently for fixed-route service:

- On-Time Performance—Demand-responsive trips have a one-hour window with respect to arrival time. A vehicle scheduled for a 10:00 a.m. pickup may arrive between 9:30 a.m. and 10:30 a.m. The "window" is two minutes for fixed-route bus service. Given that fixed-route is a new service and Community Transit wishes to expand service, reliability (as measured by on-time performance) is a critical issue to program success.
- Passenger Information—Passengers for demand-responsive service schedule trips and receive information. Fixed-route service passengers call only to request information. More detailed interaction with passengers occurs in demand-responsive service.

TRANSFERABILITY

Community Transit's program is transferable to other agencies.

HONOLULU, HAWAII: ADA PARATRANSIT SYSTEM

Agency Name: City and County of Honolulu Department of Transportation Services (Handivan)

Agency Size: Large

Transit Modes: ADA paratransit

SYSTEM PROFILE

Handivan provides ADA complementary paratransit for the City of Honolulu. Oahu Transit Services, Inc., (OTS) provides fixed-route service through TheBus and ADA paratransit service through Handivan. OTS has administered the ADA contract since 1999. Eligibility and program administration is conducted by the City of Honolulu.

Handivan can be characterized as a large paratransit operation with an annual budget of $12 million per year or about 10 percent of the total transit agency's operating budget while providing about one percent of the agency's trips. During the fiscal year ending June 30, 2001, OTS provided 733,047 rides a 6.8 percent increase over the prior year. The increase in total service hours was more modest. Total service hours in fiscal year 2001 were 348,489, a 3.09 percent increase over the prior year.

PROGRAM GOALS AND OBJECTIVES

The goals and objectives of Handivan's performance-measurement program are to

- Provide quality service,
- Meet ADA requirements, and
- Manage the increase in operating hours through increased productivity.

The measures used are

- Total annual ridership,
- Subsidy per passenger,
- Cost per vehicle hour,
- Total passenger complaints,
- Total passenger commendations,
- Van miles per trouble call,
- Vehicle accidents,
- Late trips, and
- No shows and late cancellations.

MONITORING AND REPORTING

Indicators are reported to the City and County of Honolulu on a monthly basis.

SUCCESSES AND CHALLENGES

Successes with the performance-measurement program include

- Increased service level productivity,
- Improved on time performance, and
- Reduced no-shows.

Challenges with the performance measurement system include

- Lack of real-time data because the system does not use Automated Vehicle Locators (AVL) or Mobile Data Terminals (MDT) and
- Ensuring accurate data with people using new technologies (i.e., scheduling software).

ADA requirements shape the manner in which Handivan provides service. Handivan does not deny any trips. Eighty percent of its trips are by subscription during peak hours of service, and it works to estimate the remaining demand to assist in allocation of resources. Passengers also gain more certainty with respect to trip travel times and routes.

While the ADA level of service must be provided, Handivan is committed to providing higher-quality service when possible. Often, Handivan provides a higher level of service while attempting to manage service hours and control costs. ADA paratransit is viewed as a valuable and important service, but its rapid growth can negatively impact fixed-route services (which provide nearly 70 million trips per year).

Improving performance can mean providing additional mobility options for persons with disabilities who use Handivan. Quality goals are therefore not simply improving Handivan service but improving the overall level of transportation service available to persons with disabilities. Additional mobility alternatives have developed on TheBus in recent years, including

- Flexible routing on some more distinct routes that allows curb-to-curb service,
- Travel training for fixed-route service, and
- Accessible fixed-route service (TheBus vehicles are 100% accessible).

Demand-responsive service and fixed-route service are provided differently. OTS considers vehicle load factors the most critical performance measure for fixed-route service; passenger per hour productivity is the most critical factor for demand-responsive service. Fixed-route emphasis is providing the most service and in an efficient manner. Demand-responsive focuses on efficiency in scheduling and service delivery whereby that will allow quality service through effective routing and husbanding of resources. Nevertheless, fixed-route and demand-responsive share common goals:

- Quality service to customers,
- Safe and comfortable transportation,
- Courteous and sensitive vehicle operators, and
- Reliable on-time performance.

Transferability

The program would be transferable to other systems.

Denver, Colorado: Large System

Agency Name: Regional Transportation District (RTD)

Agency Size: Large

Transit Modes: Fixed-route bus, light rail, ADA paratransit

System Profile

The Colorado state legislature created the RTD in 1969 to oversee transit service in Denver and seven counties. RTD's mission is "to meet our constituents' present and future transit needs by offering safe, clean, reliable, courteous, accessible, and cost-effective service throughout the district." There are approximately 2,400 square miles in the service area. RTD maintains a fleet of over 1,100 buses, 30 light rail vehicles, and 185 access-a-Ride demand-responsive vehicles. RTD provides several special services in addition to access-a-Ride, including special events shuttles and van pools. In 2001, RTD provided approximately 82 million trips.

Measures, Standards, and Targets

RTD has a three-tiered performance measurement system, consisting of Service Standards, a Quarterly Progress Report, and an Annual Report. Service standards have been in place the longest—over 25 years. There are numerous measures in each report category. Key economic performance measures are subsidy per passenger and passengers per mile. The Quarterly Progress Report addresses complaints, schedule adherence, and accident ratio (e.g., vehicle accidents per 100,000 miles traveled).

Service standards and economic performance measures are identified for seven classes of service:

- Local-CBD,
- Local-Urban,
- Local-Suburban,
- Express,
- Regional,
- Demand-Responsive, and
- skyRide (service to Denver International Airport).

RTD has formal performance standards through its Service Standards. The standards are updated about every three years. If a measure fails to meet its standard, or exceeds its standard, service adjustments are made. RTD reassesses service if economic performance measures are 10 to 25 percent or more below or above average. (The exact percentage varies by measure.)

Data Collection Procedure

Data for the measures are collected from the farebox and automatic vehicle location (AVL) system, as well as from the RTD Finance Department. RTD staff views the data collected as being very useful. The data are used to make service planning decisions: restructuring service, eliminating service, and adding new service.

RTD also measures “softer” indicators. RTD conducts an on-board customer survey annually, covering one or two service classes. Several evaluation categories relate to the degree of customer satisfaction. A complete survey of all service classes takes four years. RTD also conducts a random telephone survey by county every year. The survey size is based on each county’s population. RTD is committed to collecting this information every year.

Monitoring and Reporting

Economic performance measures are determined annually, while measures used in the Quarterly Progress Report are measured every three months. The measures in the Quarterly Progress Report are related to a set of goals and objectives. Economic performance measures are linked to the RTD budget. The performance measures used are reviewed about every three years.

The Colorado State Legislature requires that the revenue/cost ratio for public transit systems in the state be greater than 30 percent. Revenue includes farebox revenue and other non-tax revenue, including FTA funding. There is no state funding for public transit operations.

Successes and Challenges

In the opinion of RTD staff, the performance-measurement system works fine. The Quarterly Progress Report measures are more frequent and tend to be more visible to the public and media. RTD is very positive toward performance measurement in general, to help the agency effectively make service and operational decisions.

Transferability

RTD staff believe that their performance measures and standards are transferable to other regions and areas of the country.

NEW YORK, NEW YORK: COMPREHENSIVE PROGRAM

Agency Name: Metropolitan Transportation Authority – New York City Transit (MTA-NYCT)

Agency Size: Large

Transit Modes: Fixed-route bus, heavy rail, ADA paratransit

SYSTEM PROFILE

MTA-NYCT is the largest transit agency in the U.S. It was formed in 1953 to manage the subway system and the bus routes previously operated by the New York City Board of Transportation. MTA-NYCT is governed by a president and 12 department heads, who report to the MTA Executive Director. The agency maintains a fleet of approximately 4,500 buses, 5,800 heavy rail vehicles, and 150 demand-responsive vehicles. In 2000, MTA-NYCT provided approximately 822 million unlinked bus trips, 1.7 billion unlinked rail trips, and 473,000 unlinked paratransit trips. Additional paratransit services are contracted to several private operators.

MEASURES, STANDARDS, AND TARGETS

MTA-NYCT has numerous performance indicators and performance-measurement programs in place. MTA-NYCT uses customer-oriented indicators such as service reliability and surveys of customer perceptions. MTA-NYCT also uses several community-oriented indicators.

MTA-NYCT's performance-measurement programs include

- *Department-level indicators*—These are self-reported to the president or board and used for internal purposes.
- *Agency-wide indicators, including safety and security indicators*—These have been generated for many years.
- *Subway and bus service indicators*—There are two customer-oriented indicators reported on a quarterly basis by Operations Planning to the president and board. These indicators were established in 1995 and revised in 2001 to better reflect customer perceptions. These indicators are used by operating departments to (1) initiate specific programs (e.g., road dispatchers) addressing problem areas and (2) assess the success of specific programs to improve service.
- *Passenger environment survey (PES)*—A collection of numerous indicators measure the passenger environment of subway cars, stations, and buses. These indicators are reported on a quarterly basis by Operations Planning to the president and board. The PES began in the mid-1980s and was significantly restructured in 1995 and 2001 to better reflect customer perceptions. PES indicators are reported to the relevant operating department, which decides whether steps should be taken to address problematic areas.
- *Market research*—Market share panels started in 1995. This measure is reported by MTA-NYCT on a quarterly basis. An annual citywide survey of attitudes of bus and subway service is also performed.
- *Financial reports*—Financial and ridership reports have been generated for many years and are presented to the board, comparing year-to-date budget and actual financial results; and monthly and

year-to-date subway and bus ridership on weekdays and weekends, for the current year and the previous year.

- *Capital program status*—MTA-NYCT reports key capital project milestones (planned vs. achieved) in dollars and on a percentage basis. The capital program status reports have been ongoing for many years.
- *Departmental goals report and strategic business plan*—These are considered the most important indicators. The departmental goals report is an internal document with about 75 indicators. The Strategic Business Plan has been reported to the State since 1988 and contains 14 indicators.

A full listing of all of the measures used by MTA-NYCT is not possible in this brief summary. However, the companion Background Document (provided on the CD-ROM accompanying this Guidebook) summarizes a number of documents using these measures, including those documents listed below under "Reports and Standards."

Successes and Challenges

The major issues of MTA-NYCT's performance-measurement programs are

- *Prioritizing indicators (since there are so many of them)*—The question becomes, which ones should be reported to the president and the board?
- *Objectivity*—To ensure objectivity as well as a customer-oriented perspective, Operations Planning was given the responsibility of collecting and reporting bus and subway indicators.
- *Customer focus*—Changes to indicators reported by Operations Planning are made to better reflect the customer experience (e.g., revisions to the bus and subway indicators in early 2001 and PES indicators in 1995 and 2001).
- *Technology*—Because manual data collection and reporting result in a long time lag between the actual results and reporting, automated data collection and on-line reporting alleviates this lag (e.g., Department of Buses on-line indicator report).

Reports and Standards

Performance measure results are incorporated into a number of documents, including the ones listed below. Descriptions of these documents are in the companion Background Document provided on the accompanying CD-ROM.

- *2000 Citywide Survey—New York City Resident's Perceptions of New York City Transit Services*
- *New York City Transit Committee Agenda*
- *Rapid Transit Route Design Guidelines*
- *Rapid Transit Loading Design Guidelines*

- *Local Bus Schedule Guidelines – Route Performance Indicators*
- *Service Change Procedures*
- *Passenger Environment Survey (1995 and 2001)*
- *MTA's 2001-2005 Strategic Business Plan*
- *2001 Department Goals*

SYDNEY, AUSTRALIA: MEASURING AGENCY GOALS

Agency Name: State Transit (ST)

Agency Size: Large

Transit Modes: Fixed-route bus, ferry

SYSTEM PROFILE

State Transit operates over 1,900 buses and over 30 ferries under three distinct business units, namely Sydney Buses, Sydney Ferries, and Newcastle Buses and Ferries. It is the Australian transit operator with the largest bus and ferry fleets, carrying over 600,000 passengers daily (over 220 million passengers per year) using 15,000 vehicle trips. It is a large employer with over 4,700 staff. The services are mainly commuter-oriented, with a.m. and p.m. peak periods making up over 50 percent of total bus patronage. In total, ST operates over 1,000 kilometers on 360 routes with an average of 20 minutes per passenger trip (for an average distance of 5.7 kilometers).

PROGRAM GOALS AND OBJECTIVES

State Transit was set up in 1997, and the performance-measurement systems began then. There are 30 different contract areas that need to be reported to the New South Wales (NSW) Department of Transport, the contracting agency.

The performance-measurement program is designed to monitor the way in which State Transit meets its goals and objectives, under legislation that sets the operator as a trading enterprise. This legislation required that an overall business management system be put in place, one that can be adequately assessed. At the corporate level, the main ST goal is to "contribute to the development of a sustainable urban environment by attracting travelers on to public transport."

The Transport Administration Act defines the following objectives as having equal importance for State Transit:

- Operate efficient, safe, and reliable services,
- Maximize the net worth of the State's investment in State Transit,
- Be socially responsible,
- Be environmentally responsible, and
- Be responsible toward regional development and decentralization.

To achieve the main goal, a number of objectives have been defined. The level of detail and quantification of performance measures directly related to each objective varies depending on the objective. Some are quantified while others are given a qualitative treatment.

The main objectives identified as key to achieving the main goal have to do with improving

- Levels of coverage (new and innovative services),
- Accessibility levels,
- Reliability,
- Convenience,
- Safety and security of passengers,
- Comfort,
- Staff training to provide "friendly" service,
- Travel information to passengers, and
- Efficiency to keep costs down and fares affordable.

Most of the objectives have measurable indicators to help monitor achievement levels. Those indicators are seen as very important in driving all levels of the organization and as a means of communicating to all stakeholders what is going right and what needs improving.

Most proposals related to capital expenditure need to be evaluated using one or more of the above objectives. Management decisions at the operational level are made with regard for the way in which the objectives may be affected. For example, the bus maintenance performance target is to have no preventable (through regular maintenance) mechanical failures. The number of buses affected by each main type of problem is monitored regularly, and special programs are put in place to reduce specific problem areas.

The performance-measurement system is also designed to monitor State Transit's "Guarantee of Service," which is a publicized pledge on customer service standards. A "Quality Service Charter" states the main service related goals as

- To ensure that service delivered reflects the travel needs of customers;
- To operate buses with excellent safety standards for the benefit of passengers, staff, and the general public;
- To provide bus services that meet high standards of frequency, timeliness, reliability, and cleanliness;
- To provide customers with complete, easily understood, and up-to-date service information about bus services;
- To develop a reputation for customer service through polite, courteous, and helpful staff; and
- To make services more accessible for all passengers.

MEASURES, STANDARDS, AND TARGETS

As a result of the main corporate goal, the main performance measures driving the organization are the level of patronage in general and the transit mode share in particular. These measures are consistent with the State Government goals of reducing car dependency and improving air quality.

ST monitors closely the way in which it is able to fill off-peak seats (thus increasing patronage at low marginal cost), as well as making inroads into the segments of the market for which there is considerable latent demand (e.g., recreational and leisure trips). Patronage levels are monitored by time period (a.m. and p.m. peaks, off-peak, and weekends).

The usual financial and operational indicators are used to monitor performance and are reported on, for each of the three main business units listed above. Examples are as follows:

- Revenue, expenses, and cost recovery;
- Patronage;
- Kilometers run;
- Revenue per passenger and revenue per kilometer;
- Passengers per vehicle kilometer;
- Cost per vehicle kilometer; and
- Passengers per employee.

In addition, performance measures are used to monitor the way in which each of the main objectives of ST is being met. These are discussed in more detail in Table 2.

The service agreements with the NSW State Government cover financial performance, as well as levels and quality of service. The levels of fares are set by an independent tribunal and are based on cost-effectiveness, quality of service, and cost-of-living benchmarks.

Data Collection Procedure

Four main systems are used to collect data that can be used to monitor performance, namely

- A fuel scanning system (transponder-based with readers at depots logging bus ID, fuel used, and kilometers run);
- Scheduling software (timetabling, crew rostering, and bus scheduling).
- Automatic fare collection (AFC) which reduces boarding times by as much as 30% compared with other operators (this system also provides patronage and ticket sales data); and
- A payroll system (which provides labor cost data).

The four systems are integrated into a single management reporting system: the Executive Information System (EIS). This is an ORACLE-based product developed in house. (EIS led directly to State Transit winning a New South Wales Public Service Award.)

The State Transit Automated Ticketing System (STATS), due to be introduced in the near future, will be used to collect information on the use and performance of services. For example, on-time running will be monitored throughout journeys and at key points by STATS.

Table 2. State Transit Objectives and Related Performance Measures

Objective	Performance Measures
New and Innovative Services	Numbers and types of services introduced Patronage by route, time of day, and day of week Monthly and annual patronage
Accessibility Levels/Convenience	Percent of population living within 400 meters of a bus stop between 6 a.m. and 6.30 p.m. Monday to Saturday, and within 800 meters at other times (target: 95%) All routes connect to regional centers (yes/no) Community consultation activities are held frequently (yes/no) Customer satisfaction (from regular attitudinal surveys) Customer complaints: number of complaints of each type Bus fleet composition: targets are 25% low floor; 20% wheelchair accessible; 35% air-conditioned
Reliability	On-time running (no later than 5 minutes) in normal traffic conditions (target 95%). On-time running is measured at route terminus (buses and ferries) and at mid-points along the route (buses). Early running (target: 0%) Mechanical failures preventable through regular maintenance Number of changeovers (buses that require in-service replacement) per 100,000 kilometers (target: 98% mechanical reliability for buses)
Safety and Security of Passengers	All buses fitted with CCTV units (yes/no) All buses in radio contact with control center (yes/no) Non-slip floors on all buses (yes/no)
Comfort	Average fleet age (12 years is the contractual obligation) Number of buses air-conditioned, accessible to people with disabilities, with quality seating, and low-floor Percent of buses cleaned internally daily; percent of buses washed every 3 days Percent of buses purchased that are environmentally friendly (target: 100%)
Staff Training to Provide "Friendly" Service	Standards set for customer service training Help available for customers who do not understand the system On-going communication of decisions
Travel Information to Passengers	Percent of public timetables reviewed within a set period (target: 100%) Number of transit shops Numbers of agents selling tickets and providing information
Efficiency to Keep Costs Down and Fares at Affordable Levels	Average operating cost per passenger trip for buses Average operating cost per passenger trip for ferries Cost per vehicle-kilometer for each main cost center

MONITORING AND REPORTING

The EIS is used to obtain management reports which can be used by all levels of the organization. The performance reports are able to "drill down" to the level of individual bus routes by time of day. Patronage, revenue, costs, and on-time running can be obtained for individual routes for any time period specified. Typical reports that are generated using the EIS include

- Annual reports—the Corporate Plan; Annual Report; the annual submission to the fare-setting tribunal; and reports to the State Government Department of Transport as the contracting agency. The State Department of Transport is developing a Performance

Assessment Regime (PAR), which is intended to be applied to all bus operators in NSW.

- Monthly reports for the Board and for functional units.
- Weekly and daily reports for functional units.

Data on operating performance are used on a daily basis in a variety of ways for operations management and for ongoing review (e.g., daily maintenance checks). Some of it is also used for other purposes (e.g., bus kilometers is used to negotiate advertising contracts).

Strategic planning and service reviews make use of EIS on an ad-hoc basis. Specific objectives, which may take on added importance at times, can also be monitored using EIS; and purpose-designed reports can be obtained (e.g., days lost through injury).

Passenger surveys are conducted on a regular basis. A recent survey found that passengers rate bus services 7 out of a possible 10 points, in terms of meeting expectations. This survey also found that passengers would be "willing to pay" an additional 79 cents (Australian) per trip, on average, to move from a base level of service to an "optimum" service. Other bus service features and their ratings were:

- Passenger information: 6.0;
- Bus stop infrastructure: 5.9; and
- Bus quality and ride: 6.6.

Integrated Transport Information Service (ITIS) is a service which provides comprehensive integrated information on bus (both State Transit and private-sector operations), ferry, and rail services. The service is accessed by telephone and by Internet. The most popular information drawn from ITIS includes departure/arrival times (next service), followed by trip planning and special events travel. ITIS is used to alert passengers of service changes, interruptions, and special events. When fully developed, ITIS will be able to deliver real-time passenger information through a diverse range of outlets.

Performance monitoring reports are used extensively to communicate with staff at all levels. Feedback on performance is used to motivate staff.

SUCCESSES AND CHALLENGES

EIS is seen as a tool that provides the best competitive advantage for State Transit. EIS provides value for all functions from day-to-day management to strategic planning and forecasting. Above all, EIS helps drive efficiency in operations. Lessons and challenges include the following:

- To be successful, the program must have a strong internal champion.
- The program needs adequate resources to be properly maintained.
- There must be a dedicated training program for new staff.
- Staff need to be encouraged to learn about the full capabilities of the system, even though they may be dealing with a small part of it for most of the time.

- The system's network computing environment needs upgrading (it went "live" 5 years ago).
- The upgrade will add new functions, including the ability to customize reports to suit specific needs.

TRANSFERABILITY

EIS could be transferred to other operators that use the same scheduling software.

LANSING, MICHIGAN: CUSTOMER SATISFACTION

INTRODUCTION AND BACKGROUND

Agency Name: Capital Area Transportation Authority (CATA)

Agency Size: Medium

Transit Modes: Urban fixed-route bus, ADA demand-responsive service

CATA has been conducting its Fixed-Route Customer Satisfaction Survey for over a decade. Issues that drive customer satisfaction, such as on-time performance, Sunday service, and presence of nuisance behavior, are identified and presented in a Summary Report (***18***) and targeted for improvement.

As an example, in the 1999 survey, nuisance behavior was the primary issue influencing customer satisfaction, having the most occurrences in the past 30 days. CATA decided to address the problem by taking on a "zero tolerance" policy, which was publicly posted. Also, security on buses and CATA's transit center was stepped up to enforce the policy. The survey in the following year revealed that the policy had indeed had the intended effect. The number of occurrences had decreased significantly and the rating of satisfaction on the issue had increased, as did overall satisfaction.

Two issues are the focus of customer satisfaction research at CATA:

1. Understanding the customer's expectations and requirements and
2. Determining how well the agency is succeeding in satisfying these expectations and requirements.

The objectives of the customer satisfaction survey program are to do as follows:

- Provide a clear definition of the characteristics of existing riders and how these characteristics have changed over the years;
- Provide an overall measure of customer satisfaction and loyalty;
- Demonstrate the relative impact of the various satisfiers and dissatisfiers on overall perceptions of agency service quality;
- Identify actions that will lead to increased satisfaction; and
- Provide detailed data on riders' current method of fare payment, perceptions of value for fare paid, and reactions to proposed fare changes.

Satisfaction is measured at the route level; that is, routes are grouped into specific categories based on type of service. Statistically significant changes from the previous year are noted for overall satisfaction and individual service quality attributes. (It is interesting to note that, in addition to the typical attributes, the way in which information about CATA is obtained by the customer is solicited. The 2000 survey results indicated that customers are more likely to look for CATA information on its website than call or visit the customer service information center.)

In the 2000 survey, the following were identified as the main contributors to satisfaction and/or have a high problem occurrence rate:

- Ensuring that buses arrive at the origin stop on time,
- Improving service frequency,
- Ensuring that passengers are free from nuisance behavior while waiting at the CATA Transportation Center and at bus stops,
- Adding shelters at bus stops,
- Improving lighting at bus stops,
- Providing sufficient seat availability on buses, and
- Ensuring that buses drop off riders on time.

Other attributes were identified for specific route groups:

- Safety from crime,
- Accurate information given by phone,
- Cleanliness and condition of bus stops,
- Availability of shelters,
- Courtesy of the bus driver,
- Courtesy of the telephone information representative,
- Convenient access to information,
- Mechanical reliability of the bus,
- Availability of seats on the bus,
- Clarity of route and schedule information, and
- Comfort of seats on the bus.

The following are some of the recommendations from the 2000 survey:

- The focus on nuisance behavior was effective and should be continued.
- The addition of bus shelters should be explored.
- Crowding and lack of seating on Michigan State University (MSU) campus buses are problematic and should be addressed.
- CATA's website should continue to be upgraded, due to the increasing usage of the website to obtain CATA information.
- Among the newest riders, the effectiveness and clarity of schedule and timetable information appear to be a concern that should be addressed.

METHODOLOGY

The "Impact Score" or "Things Gone Wrong Approach," as it is called in the automotive industry, is used to identify the attributes that drive customer satisfaction. This is the same method recommended in *TCRP Report 47* (**4**).

The major differences or additions to the *TCRP Report 47* method are (1) sections in the survey on Customer Loyalty and Price Sensitivity and (2) the use of Quadrant Analysis in reviewing the responses. These elements will be described later in this section.

A total of 516 telephone interviews were conducted with CATA riders who rode CATA at least once in the past year. To obtain the sample, a larger set of CATA riders was first identified by asking customers to volunteer for the research via an on-board survey. Of the 1,800 riders who volunteered, 516 were randomly chosen from a computerized database. Routes were categorized by route characteristic, and the sample was stratified so that approximately 80 interviews were performed per category. The results were later weighted to reflect ridership levels per route category. All results are reported in terms of the weighted sample. However, in making statistical inferences, the unweighted sample is used. The level of confidence is 95% and the margin of error is ± 4.4%.

QUESTIONNAIRE

The telephone interview questionnaire contains 134 questions, using a 7-point scale, with 1 representing "not at all satisfied" and 7 representing "extremely satisfied." A total of 38 transit service attributes are surveyed:

- Cleanliness of the bus stop area where the rider gets on or off the bus;
- Condition of area surrounding the bus stop or shelter;
- Availability of shelters at the bus stop throughout the CATA service area;
- Lighting at the bus stop;
- On-time arrival of the bus at the stop where the rider gets on;
- On-time arrival of the bus at the stop where the rider gets off;
- Amount of time between buses;
- Directness of the route;
- Courtesy of the bus driver;
- Clear and timely announcements of the next stop;
- Driver operation of the bus in a safe and competent manner;
- Cleanliness of the bus;
- Comfortable temperature on the bus;
- Ease of getting passes or tokens;
- Clarity of printed route and schedule information;
- Ease of making connections to another bus;

- Safety from crime where the rider gets on or off the bus;
- Safety from threatening behavior and crimes, such as robbery and assault, while riding on the bus;
- Personal safety from threatening behavior and crimes such as robbery and assault while waiting at the CATA Transportation Center;
- Mechanical reliability of the bus;
- Operation of the bus in a manner so as to provide a smooth ride;
- Availability of seats on the bus;
- Comfort of the seats on the bus;
- Convenient bus stop locations where the rider gets on and off the bus;
- Convenient access to route and schedule information;
- Accurate information given by phone;
- Amount of time on hold when calling CATA to obtain information;
- Courtesy of the customer information representative on the telephone;
- Usefulness of route information at shelters;
- Freedom from nuisance behavior of others (e.g., intoxicated people; loud, rude, or obscene language; or bad odors) at the CATA Transportation Center;
- Freedom from nuisance behavior of others (e.g., intoxicated people; loud, rude, or obscene language; or bad odors) on the bus;
- Helpfulness of drivers;
- Driver's knowledge of routes, schedules, and service;
- Cost of a one-way ride;
- Value of service for fare paid;
- Availability of route information at bus stops or shelters;
- Bike racks on buses; and
- Availability of locations where bus passes are sold.

The average length of the telephone interviews was 21.8 minutes.

IMPACT SCORE APPROACH

The impact score approach determines the relative impacts of attributes on overall satisfaction by measuring relative decreases in overall satisfaction when a problem with an attribute is reported. Survey respondents rank the importance of specific service attributes and indicate their overall satisfaction with the system using a likert (e.g., 1 to 7) scale. The impact score approach involves the following steps.

First, the attributes that have the most impact on overall satisfaction must be determined. This is done by calculating the percentage of customers experiencing a problem with each specific attribute and comparing the mean overall ratings for customers with a problem versus customers without a problem. The difference is called the gap score. Then, a statistical *t*-test is conducted to determine significance among gap scores. Finally, a composite impact score is created by multiplying the overall satisfaction gap score by the attribute's problem incidence rate.

In the 2000 survey, CATA riders' primary drivers of satisfaction were as shown in Table 3 below. The "mean with problem" value represents the average satisfaction score provided by respondents who experienced a problem with this service element within the previous 30 days. The "mean without problem" represents the average satisfaction score provided by respondents who did not have a problem with this element. The gap score is the difference between the two scores.

Table 3. CATA Rider Satisfaction

Service Element	Mean w/ Problem	Mean w/o Problem	Gap Score	% With Problem	Impact Score
Bus arrives on time at the stop where I get on	3.97	6.10	2.14	38%	0.81
Amount of time between buses	3.76	6.02	2.26	31%	0.70
Availability of seats on the bus	4.25	6.16	1.91	35%	0.67
Freedom from nuisance behavior of others at the CTC	3.77	6.21	2.44	28%	0.66
Freedom from nuisance behavior of others on the bus	3.79	6.08	2.29	27%	0.64
Availability of shelters at the bus stop	3.17	5.70	2.53	25%	0.63
Lighting at the bus stop	3.04	5.86	2.82	17%	0.48
Bus drops me off at the stop where I get off on time	4.24	6.33	2.09	21%	0.44

Customer Loyalty

Three questions related to customer loyalty were added to the survey in 1998. These questions are

1. Overall, how satisfied are you with riding CATA?
2. How likely are you to continue to ride CATA in the future?
3. How many relatives, friends, or co-workers have you encouraged to ride CATA in the past year?

The analysis focuses on responses to each question as well as a combined loyalty index.

Changes in composition of the loyalty segments along with shifts in the proportion of loyal versus less-loyal riders are examined. The following four loyalty segments are identified:

- "Secure" riders: Respondents who provided the highest rating, "extremely satisfied," to all three questions.
- "Potentially vulnerable" riders: Riders who gave the highest rating to two of the three questions.
- "Vulnerable" riders: Riders who gave the highest rating to only one of the three questions.
- "Highly vulnerable" riders: Riders who did not give the highest rating to any of the three questions.

Figure 2 presents the overall loyalty results for the 2000 survey. Table 4 presents the percentage of secure riders within each route group.

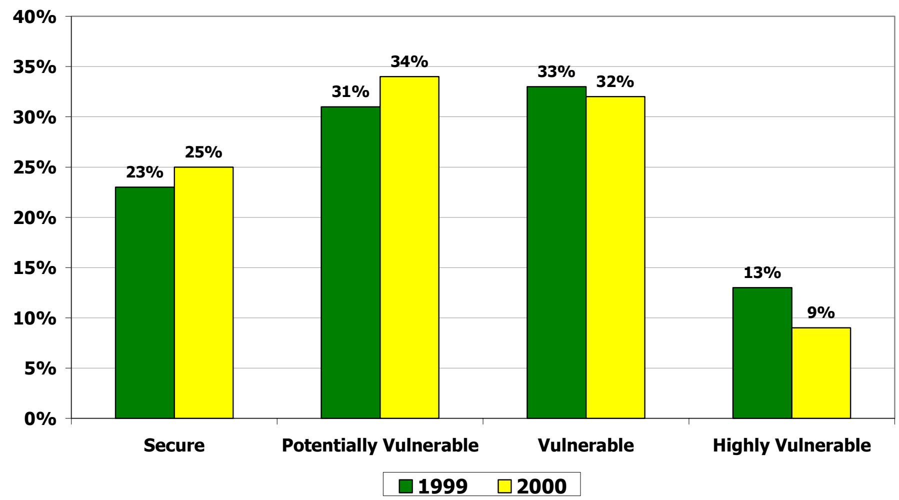


Figure 2. Overall CATA Loyalty Results

Table 4. Percent Secure Riders in CATA Route Groups

Route Group	% Secure
1	26
2	36
3	28
4	30
5	28
6 (MSU)	19

The characteristics of each loyalty category can also be summarized. For instance, the survey report mentions that secure riders "are more likely to be infrequent riders, those who have been riding for six or more years, choice riders, females, and those who are 45 years of age or older."

PRICE SENSITIVITY

The following four questions on the survey are related to customer perceptions of the value of their transit ride and customer resistance (inelasticity) over a range of fares:

- Reasonable Fare: What fare would you expect to pay for a one-way ride to receive good service for the fare paid?
- Expensive: At what point would the amount you pay for a one-way ride be expensive, but you would continue to ride?
- Too Expensive: At what point would the amount you pay for a one-way ride be so expensive, you would stop riding or ride less often?
- Too Low: At what point would the amount you pay for a one-way ride be so low that you would be concerned about the quality of service being offered?

Based on responses to these questions, the following information can be determined:

- Indifference Price Point: At this point, an equal number of respondents believe that the fare is "reasonable" as believe it is "expensive," and the remaining respondents are indifferent. This point is the price at which the maximum number of respondents is indifferent.
- Optimum Price Point: This point is the price at which an equal number of respondents perceive the price as "too low" and "too expensive." It is the point at which price-related resistance to paying an increased fare is at its lowest point.
- Stress Situation: "Stress" is defined as a situation in which a number of riders believe that the current fare is too high. The larger the separation of the "Optimum Price" and the "Indifference Price," the greater the "stress."
- Range of Acceptable Fares: The range of prices between the "Point of Marginal Cheapness" and "Point of Marginal Expensiveness" is considered the "Range of Acceptable Prices or Fares." Any price below this range will be unlikely to generate new customers, and any price above this range may have an adverse impact on revenues. The "Point of Marginal Cheapness" is the point at which the number of riders who view the price as "too low" is the same as the number who view the price as "not reasonable" (i.e., above the price considered "reasonable"). The "Point of Marginal Expensiveness" is the price at which the number of riders who believe the fare is "too expensive" is the same as the number who believe the fare is "not expensive" (i.e., below the fare considered "expensive").

QUADRANT ANALYSIS

Quadrant analysis is used by CATA to set priorities for improvement strategies. The technique identifies potential opportunities for improvement for the 38 service quality attributes. Based on the gap score for each element and the incidence of problem occurrence, the quadrants present indicators of potential problems and opportunities. This is illustrated in Table 5 below. The attributes with high gap scores as well as an above-average incidence of problem occurrence receive first priority; areas that are critical drivers of customer satisfaction and that have an above-average problem incidence also receive attention by CATA.

Table 5. Gap Score Quadrants

Gap Score	Problem Occurrence	
	High	Low
High	Opportunities	Strengths
Low	Non-Critical	Maintenance

The specific service quality attributes identified for each category in Table 5 are presented in Table 6.

Table 6. Service Quality Attributes by Quadrant

Opportunities	Strengths
Bus arrives on time—origin	Cost of a one-way ride
Time between buses	Safety from crime at stops
Freedom from nuisance at CTC	Safety from crime while riding
Freedom from nuisance on bus	Safety from crime at CTC
Availability of shelters at stops	Courtesy of telephone operator
Lighting at the bus stop	Accurate information by phone
Clear and timely stop announcements	Locations where passes/tokens are sold
Comfort of seats on the bus	Clarity of schedule information
Condition of area surrounding the bus	Helpfulness of drivers
Ease of making connections to another bus	Courtesy of bus driver
	Convenient stop locations
	Time on hold
	Usefulness of route information at stops
Non-Critical	**Maintenance**
Availability of seats on bus	Availability of route information at stops
Bus arrives on time—destination	Cleanliness of bus
Comfortable temperature	Safe bus operation
Mechanical reliability of buses	Cleanliness of bus stops
Directness of route	Driver's knowledge of routes and schedules
Smoothness of ride	Convenient access to schedule information
	Ease of getting passes/tokens
	Value of service for fare paid
	Bike racks on buses

SAN DIEGO, CALIFORNIA: METROPOLITAN PLANNING ORGANIZATION

AGENCY PROFILE

Agency Name: San Diego Association of Governments (SANDAG)

City Size: Large

Transit Modes: Urban fixed-route bus, light rail, commuter rail, and ADA paratransit service are provided in the region

SANDAG is a regional planning agency governed by several advisors and a board representing 19 local governments. SANDAG was formed in 1966 as the Comprehensive Planning Organization but was renamed in 1980. SANDAG is involved in regional transit funding and planning activities with the California Department of Transportation, the Metropolitan Transit Development Board (MTDB), the North San Diego County Transit Development Board, and other regional transit operators.

PROGRAM GOALS AND OBJECTIVES

SANDAG works closely with MTDB in preparing the regional transportation plan and transportation improvement program for the San Diego area. In the past, SANDAG generally incorporated MTDB projects. Now, however, a series of transit performance measures is being used to assess the impact and priority of transit capital projects in the new 2030 regional transportation plan (RTP). The Transit Emphasis alternative of the 2030 RTP is based on the Regional Transit Vision framework approved by the SANDAG board in November 2001. SANDAG does not get involved with MTDB's application of transit performance measures and service standards related to assessing current transit route and system operating performance.

MEASURES, STANDARDS, AND TARGETS

The impact and priority of transit capital projects in the 2030 RTP Transit Emphasis alternative is assessed using the following quantitative measures:

See the Background Document on the accompanying CD-ROM for a list of measures considered during plan preparation, but not adopted.

- *Serving Commute Needs*—percentage of route on a roadway operating at LOS "E" or "F" in 2020; subregional area (SRA) employment as percentage of highest SRA employment; average route speed; morning and afternoon peak period ridership (considered separately); morning and afternoon peak period ridership per service mile.
- *Serving Transit-supportive Corridors*—average population per square mile within ½ mile of stations; average employment per square mile within ¼ mile of stations; number of non-employment major activity centers within ½ mile of stations; midday and evening ridership; midday and evening ridership per service mile.
- *Developing Network Integration*—number of other Yellow and Red Car (serving medium- and long-distance trips) transit routes connected to; number of transferring passengers by service mile.
- *Cost-effectiveness*—subsidy per passenger mile.

Transit projects are scored one to five points for each of the criteria within the categories above. Additional project-level performance measures include estimates of operating and capital costs. Future criteria to be addressed include transit service coverage and geographic balance of projects.

Additional measures were developed for the Highway Emphasis (i.e., corridor) alternative for the 2030 RTP. These measures are weighted and include a ratio of cost to complete by person-miles traveled, a ratio of cost to complete by travel time saved, "critical link" status of corridor, accident rate (compared to statewide rate), percentage of heavy trucks, proximity to major employment areas, proximity to "smart growth" areas, encouragement of non-single-occupant-vehicle modes, compatibility with habitat preservation plans, and percentage of adjacent land use that is residential (to assess community impacts).

BALTIMORE, MARYLAND: CITYWIDE PROGRAM

Agency Name: City of Baltimore

City Size: Large

CitiStat is a citywide performance monitoring program based on the ComStat program used by the New York City Police Department. CitiStat meetings with the Mayor, bureau heads, and other City managers and staff are held every other week. Performance data are submitted to the CitiStat team before each meeting for analysis. The CitiStat team also verifies and investigates data and compares it to data from other reporting periods.

The guiding principles of CitiStat are as follows:

1. Accurate and Timely Intelligence
2. Effective Tactics and Strategies
3. Rapid Deployment of Resources
4. Relentless Follow-Up and Assessment

Two perspectives are presented on the CitiStat system: (1) a city department that collects agency-specific data and is accountable for its results; and (2) an overall City Hall perspective of how the system is applied.

OFFICE OF TRANSPORTATION PERSPECTIVE

PROGRAM GOALS AND OBJECTIVES

The CitiStat program was initiated because the mayor wanted to implement a system of accountability in City government. The system is based on the deployment of resources to better serve the citizens. The system is used as a means of quickly developing solutions to complex problems. When the system began in March 2000, its initial focus was "crime and grime." (The Office of Transportation did not participate until October 2000.)

CitiStat is a way to improve the system and processes and to change attitudes within city government. For example, vandalism in the impound lots was a problem that surfaced through CitiStat. The problem was solved through CitiStat interaction by increasing training, modifying the policies and procedures, and getting the necessary support from other agencies.

CitiStat expedites the decision-making process by bringing issues to the decision-makers and by requiring the appropriate department to take action on a particular issue. CitiStat is used to establish priorities between and within departments. The process helps the departments critically think through the decision-making process.

MEASURES, STANDARDS, AND TARGETS

See the web site at http://www.ci.baltimore.md.us/news/citistat/. (These measures are not transit-specific.) Internal measures are for performance. External measures are those visible to the public.

If a measure consistently exceeds its standard, the standard was set too low. If a measure fails its standard, then CitiStat is used to re-evaluate the process and establish improvements.

CitiStat is currently developing goals and objectives for the Office of Transportation, a new department. The transportation department staff reviewed its accounting and accountability standards. They also reviewed their critical and secondary functions. They looked for performance measures that would affect and be visible to the public (for example, potholes repaired within 48 hours). CitiStat may add to the performance measures but will not change those visible to public.

DATA COLLECTION PROCEDURE

There are no specific data collected for “soft” measures. The focus is more within a department. The progress of the projects in neighborhoods and communities is reported to CitiStat, but there are no direct polls.

MONITORING AND REPORTING

Measurements are made every 2 weeks. Issues are reported to the mayor, chief of staff, deputy mayors, and the CitiStat office every 2 weeks via a presentation by the Director and staff. The week following, CitiStat develops measures in response to the issues raised.

SUCCESSES AND CHALLENGES

The process was difficult and intimidating for participants, particularly in the beginning. However, the Office of Transportation has adopted new management techniques so that the required CitiStat reporting is less time-consuming. CitiStat can be used as a tool to uncover problems and develop solutions to those problems. The CitiStat program will expand, but not replace, other internal performance measures.

Data analysis and the forum for discussions are strengths of the program. "Lessons learned" from implementing the program include the following:

- The panel needs to be competent and know how to ask the right questions.
- The meetings need to be consistently scheduled.
- It is important for some panel members to not be subject matter experts. This allows for an outsiders' perspective.

According to Office of Transportation staff, the public is looking for accountability. CitiStat forces the agency to be responsive to the public. An issue to consider is that CitiStat could focus the department on only those things that come out of CitiStat.

CITY HALL PERSPECTIVE

PROGRAM GOALS AND OBJECTIVES

The program was initiated because the then new mayor wanted to institute a system of accountability and measurement throughout City government. The mayor had hired a commissioner to head the police department who had been involved with New York City's ComStat program for the New York Police Department, and the commissioner implemented a similar system in Baltimore City's Police Department. The program was initiated in the Police Department because this was the mayor's top campaign priority.

City departments use the CitiStat performance measures, in part, to set departmental goals. Each department is then measured against these goals. The data obtained from the CitiStat reporting can be used in the budget process (e.g., to more easily track the costs of certain budget items and then review future budgets using this information; to learn that resurfacing projects average $Y per mile or per lane mile; or to quickly determine whether a budget item is realistic). The CitiStat department terms this "activity-based costing." The CitiStat system can also be used to set priorities for the budget.

Performance measurement, in general, is essential. Without measuring what is, it is impossible to make changes.

MEASURES, STANDARDS, AND TARGETS

The performance measures were chosen in order to try to minimize the work associated with collecting the data. Once a department is brought on line, CitiStat staff will meet with a department's management team to review the reporting mechanisms that the team uses to manage the department. The two groups will then collaboratively agree on the reporting requirements for the CitiStat program.

There are thousands of performance measures, which can be viewed on the City's web site at http://www.ci.baltimore.md.us/news/citistat/. There are several measures, such as those for budget and personnel, that are included in all departments. Beyond these, the performance measures are customized for each department.

The performance indicators reflect department objectives fairly accurately, although both the CitiStat office and each reporting department are constantly refining the measures. If a measure fails its standard repeatedly, it can lead to staff changes.

DATA COLLECTION PROCEDURE

Most measurements are taken every two weeks; however, some are taken monthly. The data are useful because, in large part, the City uses this system to manage the operation of the city.

For the most part, CitiStat does not measure "softer" indicators such as customer or community satisfaction and perception, primarily because there are no reporting mechanisms in place to report the data, and because it would require additional data collection. Where such systems are in place, they do measure the softer indicators. An example is the City's Information Technology department. This department is responsible for lodging and responding to citizen complaints. They measure the satisfaction of this task by setting time limits for the response and also conduct follow-ups with a percentage of the complainants.

The program will be expanded to include all city agencies. Currently, they are not using CitiStat with some of the softer agencies, such as Human Services. After a period of time, the frequency of meetings may be reduced to perhaps once a month.

MONITORING AND REPORTING

The results are reported to the CitiStat team, which is comprised of the mayor, the deputy mayors, and the CitiStat management team. The results are reported by department staff bi-weekly at this time, although some measures are reported monthly (such as financial measures).

SUCCESSES AND CHALLENGES

The City staff is very proud of the system because of the monetary and service benefits to the citizens of the City. There is a report on the CitiStat web site that describes the cost-benefits of the program. Staff indicated that the benefits were conservative because they did not have a baseline comparison for many of the performance measures. The data output from the system is very robust and will help to improve each department more in subsequent years. The data output will also provide baseline comparisons for performance measures.

The commitment of the leadership is critical to carrying out the system. There has to be buy-in both from the City management side and at the departmental level. Having said that, some departments struggle with the data collection efforts. These are typically the departments where the biggest problems exist. The ability to analyze the data does not exist in all departments.

TRANSFERABILITY

The program is very transferable to other regions and areas of the country. The CitiStat office receives requests from agencies around the world to review their operation. To date, they have had visitors from over 100 cities, towns, and so forth, who have come to Baltimore to view the system in action.

EUROPEAN UNION: INTERNATIONAL PERSPECTIVE

PROGRAM GOALS AND OBJECTIVES

The intent of the European Union's Quality Approach in Tendering/Contracting Urban Public Transportation Operations (QUATTRO) project is to "develop and improve quality in urban public transport tendering, contracting, and monitoring procedures." (***19***) The project includes 20 partners from eight European Union countries, plus Norway, Poland, Hungary, and the Baltic states.

The objectives of the QUATTRO project consist of

- Identifying current and emerging quality management practices in the contracting of urban public transportation services with emphasis on issues of quality definition and measurement, on the clarification of the contracting parties' responsibilities, and on evaluation procedures and their impact on continuous improvement programs;
- Evaluating these practices and improving them by looking at quality management trends and best practices in industries other than urban public transportation; and
- Proposing a series of guidelines to authorities and operators involved in or interested in contracting and performance monitoring in urban public transportation, with a strong focus on quality.

Four classes of service quality are considered in detail in the QUATTRO project. These classes are (***19***)

- *Expected Quality.* "This is the level of quality anticipated by the customer and can be defined in terms of explicit and implicit expectations. The level of quality expected by the passenger can be defined as the sum of a number of weighted quality criteria. Qualitative and quantitative surveys can be used to identify these criteria and to assess their relative importance."
- *Targeted Quality.* "This is the level of quality that the operator aims to provide to passengers. It is dependent on the level of quality

expected by the passengers, external and internal pressures, budgetary constraints, and competitors' performance.... It is made up of an identified service, a level of achievement for that service, and a threshold of unacceptable performance."

- *Delivered Quality.* "This is the level of quality that is achieved on a day-to-day basis in normal operating conditions. Service disruptions, whether or not they are the fault of the operator, are taken into consideration. The relevant measurements are established using statistical and observation matrices."
- *Perceived Quality.* "This is the level of quality perceived by passengers in the course of their journeys. However, the way passengers perceive the service depends on their previous personal experiences with the service or with its associated services…. Perceived quality is therefore subject to bias."

A suggested structure for classifying transit service quality elements is presented in Table 7. This table of service quality is characterized by distinctions and components such as accessibility between taxis and transit, multiple classes of service quality, more detail on quantifying pollution, and the determinants of information quality under abnormal operating conditions. The classes in the table form a "quality loop" wherein the gaps correspond to areas where service improvements are required. Figure 3 depicts the "quality loop."

QUATTRO identifies safety and security, cleanliness, waiting time/frequency, information, ticketing system, and staff/driver attitude as features that transit agencies should always include in customer satisfaction surveys. Punctuality, speed, and response to correspondence are occasionally included.

QUATTRO addresses the types of surveys that can help evaluate transit service quality and offers guidance on developing customer satisfaction indices. It also describes "customer charters" that formalize the customer's right to reliable, quality service. These charters set passenger-oriented targets for the quality of service components identified in Table 7. Charters should be unconditional, easy to understand, meaningful, easy to refer to, and easy to fulfill. Table 8 provides an example of charter targets.

Table 7. Hierarchy of Quality Determinants in Public Transportation (*19*)

Class	Description	Determinants	
Availability	Basic coverage of the service by geography, time, and mode	Network	Distance to stops/stations; need for transfers; area covered
		Timetable	Operating hours; frequency
Accessibility	Interface with other transportation modes and physical access to transportation services	External interface	Pedestrians; cyclists; taxi users; private car users
		Internal interface	Entrances/exits to stops/stations; internal movement at stops/stations; access to vehicles; internal movement in vehicles
		Ticketing	Home ticketing; ticketing within system; ticketing at other locations
Information	Availability of information pertinent to the planning and execution of a journey or a pattern of journeys	General information	Availability; accessibility; time; customer care; comfort; security; environment
		Travel information in normal conditions	Street directions; stop identity; vehicle direction; route; time; fare; type of ticket
		Travel information in abnormal conditions	Current network status; suggested alternative; refund/redress; suggestions and complaints; lost property
Time	Time used for planning and executing a journey or a pattern of journeys	Length of travel time	—
		Punctuality	—
		Reliability	—
Customer Care	Elements needed to make the journey easier and more pleasant, typically through human presence	Commitment	—
		Customer interface	Inquiries; complaints; redress; suggestions
		Staff	Availability; attitude; skills; appearance
		Physical assistance	At service disruptions; toward mobility-impaired; toward inexperienced customers; movement of luggage, etc.; persons with strollers
		Ticketing options	Exchangeability; flexibility; concessionary tariffs (discounts); through ticketing; payment options
Comfort	Physical comfort obtained through the design of or use of installations and vehicles or through ambient conditions	Ambient conditions	Air quality and temperature; weather protection; cleanliness; brightness; congestion; noise; intrusive activity
		Facilities	Seating and personal space; toilets/washing; luggage and other objects; communication; refreshments; commercial services; entertainment
		Ergonomics	Ease of movement; furniture design
		Ride comfort	Starting/stopping; during travel
Security	Actual degree of safety from crime or accidents and the feeling of security resulting from that and other psychological factors	Safety from crime	Staff/police presence; lighting; visible monitoring; layout; identified help points
		Safety from accidents	Presence/visibility of supports; avoidance/visibility of hazards; active safeguarding by staff
		Perception of security	Conspicuousness of safety measures; "mastery of network"; press relations
Environmental Impact	Effects on the environment resulting from public transportation	Pollution	Emissions; noise; visual pollution; vibration; dust and dirt; odor; waste
		Natural resources	Energy; space
		Infrastructure	Effect of vibrations; wear on road, etc.; capacity demand; disruption

Figure 3. QUATTRO Quality Loop (*19*)

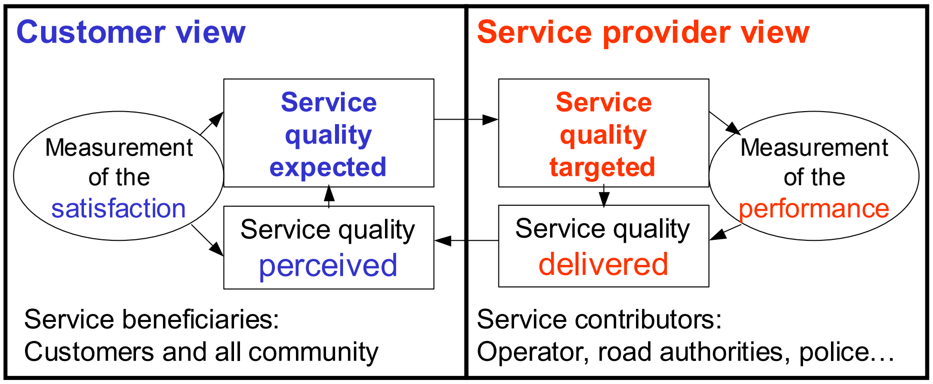


Table 8. Example Content of Customer Charter of Commitment (*19*)

Goal	Measure	Target
Travel time	Punctuality Regularity Travel Time	98-99% 65-95% 95%
Accessibility	Elevators/escalators Walking distance	Functioning 90-96% Maximum 400-700 meters
Cleanliness	Frequency of sweeping/washing Remove graffiti/hazards	– –
Comfort	Having a seat	Always seats in off-peak periods; maximum 15-minute standing period in peaks
Information	Reply to complaints Telephone reply	7-15 days 0.5-3 minutes
Ticket selling	Waiting time Ticket machines (giving change)	Maximum 3 minutes Functioning 98%

SYDNEY, AUSTRALIA: PRIVATE OPERATOR

SYSTEM PROFILE

Agency Name: Busways

Agency Size: Medium

Transit Modes: Urban fixed-route bus

Busways operates 310 buses from 5 main depots in the Sydney metropolitan and Central Coast areas. It carries over 100,000 passengers daily and serves mainly the commuter and school markets. It employs over 550 staff.

Busways started life as a one-bus operation in Sydney in 1942, and it has become the second largest private bus operator in the region. Several studies in the 1990s identified Busways as one of the most efficient bus operators in Australia, in terms of cost recovery levels. The company continues to provide an adequate return on investment for its owners.

PROGRAM GOALS AND OBJECTIVES

The company's major performance efforts are designed to achieve its three main overall goals, namely,

1. **Customers** and potential customers should be provided with an efficient, effective, and safe system.
2. **Employees** should be provided with a working environment that will enable them to enjoy a high level of job satisfaction.
3. **Owners** should enjoy an adequate return on their investment to enable the business to continue to grow.

MEASURES, STANDARDS, AND TARGETS

To achieve the three main company goals, there is an emphasis on "customer care" and on cost-efficient operations. These two areas will be discussed in more detail below.

CUSTOMER CARE

Patronage levels are monitored by time period (i.e., a.m. peak, p.m. peak, off-peak, and weekend). Contracts with government agencies provide for revenue from two sources, namely,

- School transportation (based on a percentage of the number of school children with bus passes, currently set at 77%).
- Pensioner (senior) trips (50% concessional, or discounted, fare applies to pensioners).

The government transportation planning agency sets minimum frequencies for peak and off-peak time periods, and operators are free to exceed those minimums as they see fit.

Busways operates frequencies which are higher than the minimum level for all time periods. There has been a conscious decision to provide a "comprehensive" level of service in the areas under Busways operations. This means providing bus frequencies during off-peak periods (including night times) and weekends, which would not normally be provided on a direct cost recovery basis. These services are cross-subsidized within the company, to maximize customer loyalty and to encourage customers to continue to use transit, rather than buying a second car, for example.

In addition to monitoring on-time running (drivers radio-in when delays are longer than 10 minutes and appropriate action is taken), there is an emphasis on using three dedicated staff to perform customer service duties exclusively, on a roaming basis throughout the system. These employees are in direct contact with customers and are used as the "eyes" and "ears" of management to ensure that the operating plan works successfully. They also act as "troubleshooters" to solve on-the-spot problems (e.g., ticketing issues and missed connections).

The bus/rail interchange is an important task for Busways at five main railway stations. During peak times (3 p.m. to 7 p.m.) at these stations, coordinators are present to ensure that passengers do not miss their planned connection (each bus run is linked to a specific train that may run late at times). These coordinators are bus drivers at other times of the day. This practice allows employees to perform different functions and to experience at first hand customers' requirements and problems.

Customer information is provided at all bus shelters. Timetable information is also provided to passengers at stops where there is no bus shelter, using waterproof material.

Busways uses two contractors to monitor performance on buses and at bus/rail interchanges. By traveling as passengers, these contractors are not recognized by the staff and are able to report to management on the performance of drivers (customer relations) and on any other problem encountered by passengers. These reports are provided directly to the General Manager.

Customer service is monitored by the use of customer surveys which are conducted at regular intervals. In more recent times, there has been a move to conduct surveys of potential customers using other than on-board bus surveys, such as local newspapers and mailbox drops.

Busways also employs an Infrastructure Planning Manager and an assistant who consistently work with local councils, Roads & Traffic authority, and other infrastructure developers to ensure that all planned developments are "bus friendly" and the necessary bus priority measures are introduced. In new development areas, these staff ensure that the roads are built to accommodate large buses. Busways also attempts to provide services to the new area as soon as the first houses are being built. While this is unprofitable in the short term, it ensures that long-term loyalty is maintained.

COST-EFFICIENT OPERATIONS

The usual financial and operational indicators are used to monitor and report performance, including

- Revenue, expenses, and cost recovery;
- Patronage;
- Kilometers run;
- Revenue per kilometer;
- Passengers per vehicle-kilometer;
- Cost per vehicle-kilometer; and
- Passengers per employee.

There has been a policy of standardizing the bus fleet so that all buses are of approximately the same size. This allows easy interchanging of buses on different runs as well as reducing operating and maintenance costs, through standardization and economies of scale.

The company monitors maintenance costs and fuel consumption continuously. The latter is monitored for every bus, and a rate in liters per 100 kilometers (the metric version of miles per gallon) is calculated on a weekly basis. The reports are analyzed at the maintenance manager level and action is taken for abnormal consumption rates.

Maintenance costs are monitored and the results for each depot are compared. The management of the maintenance function receives significant attention (the Director of Maintenance has overall responsibility and works with Group maintenance managers and with individual Workshop managers).

Scheduling (bus and crews) has eight full-time employees to ensure that dead running is minimized and that overall efficiencies from the use of software are achieved in practice.

SUCCESSES AND CHALLENGES

The main lessons from Busways relate to customer-centered performance, coupled with a very cost-conscious management outlook. This cost minimization relates to identifying inefficiencies, rather than on cutting services. Busways relies more on first-hand performance monitoring, with an emphasis on customer contact, to gain a good understanding of needs and problems. In particular, the use of "station coordinators" at bus/rail interchanges has proved very successful for Busways. This reliance on a human face to monitor performance means that the quantification aspects of measurement play a secondary role to the direct employee contact.

TRANSFERABILITY

The policies described above could easily be adopted by other operators. Although Busways uses state-of-the-art technology and software in some of its functions (e.g., scheduling), it places a great deal of reliance on its employees in the monitoring of customer service and in finding ways to reduce operating costs.

ELECTRIC UTILITY: PRIVATE INDUSTRY EXAMPLE

Private Industry Company Type: Electric Utility Company (name withheld)

Case Topic: ISO 9000:2000 certification – total quality management approach

GENERAL BUSINESS PROBLEM

Given the expectation that deregulation will occur within their service area by 2002, this company made ISO-9000: 2000 certification a priority, to gain an advertising and customer confidence advantage over new competitors in their market. A new CEO also wanted to use this approach in setting goals and in establishing a Total Quality Management System (QMS). The system is a collection of processes, documents, resources, and monitoring systems that direct the work of an organization regarding product and service quality. The organization needs to establish, document, carry out, and maintain this system to meet the requirements of ISO 9000:2000.

SETTING OBJECTIVES

Using ISO 9000 guidelines, the company needed to first document—either electronically or on paper—a quality policy, quality objectives, and a quality manual (http://www.isoeasy.org/). The quality manual describes all of the quality procedures developed to meet objectives and the interaction between processes making up the QMS.

ISO standards require the involvement and commitment of an organization's top management in the development of the quality program. The company's Executive Committee was assigned the following responsibilities:

- Overseeing the creation of the Quality Management System;
- Communicating the importance of meeting requirements, including customer, legal, and regulatory requirements;
- Ensuring that customer requirements are understood and met with the goal of improving customer satisfaction;
- Establishing the quality policy and the quality objectives;
- Communicating with parties responsible for product and service quality;
- Providing adequate resources and training for operating the QMS; and
- Reviewing the operation of the QMS.

The Executive Committee explored the expectations of all company stakeholders (i.e., shareholders, board members, customers, employees, suppliers, regulatory officials, and the public) through a series of workshops. Based on feedback from these workshops, the Executive Committee developed the following quality policy:

> "____ is committed to the development and implementation of quality processes that will ensure continuous improvement in customer satisfaction."

This policy was communicated throughout the organization, including prominent postings at all frontline employee sites and appearing across computer screens whenever employees log in.

Measurable quality objectives were designed to achieve the following goals:

- Be more efficient and profitable,
- Achieve improved customer satisfaction,
- Maintain and increase market share,
- Improve communications and morale within the organization,
- Reduce reported service disruptions, and
- Increase confidence in the service system.

A manager within the organization was appointed to have ongoing operational responsibility for the development and maintenance of the QMS. In addition, the Executive Committee appointed a cross-functional task force of employees to develop QMS procedures and the quality manual. The Executive Committee also hired an independent ISO 9000 Standards consultant to assist the manager and the task force with development of the QMS and to set up a quarterly review process to assess progress and results.

USE OF MARKET RESEARCH

An annual customer satisfaction research program was established to track overall satisfaction with service and to analyze the relative impact of dissatisfaction with individual service elements on the overall satisfaction measure. The QMS manager and task force used these benchmark customer research results to develop and prioritize a list of service monitoring performance measures. These performance measures set the areas of concern for the assessment and development of quality processes.

SPECIAL TOOLS, PRODUCTS, AND METHODS

The customer research identified service disruptions and the ease of getting information about billing concerns as the primary areas in need of continuous quality improvements. The task force took apart the detailed activities that must be accomplished and interrelated if service disruptions are to be avoided or minimized. The task force also looked at the activities that must occur if customer-billing inquiries are to be handled successfully. Service requirements and objectives were developed and documented for each of these areas, including performance objectives and measures.

All of the necessary activities for successful performance were thoroughly identified in flow charts. Simple forms were developed as "check-offs" or validations to document the full and proper completion of each activity in the chain. The task forced reviewed the people and resources affecting service in these areas in terms of their ability to carry out the work. Skills and training needed were documented and assessed, as well as workspace, equipment, and supporting services. Training and resource needs were documented and included as steps in the quality manual.

MANAGEMENT ORGANIZATION

The Executive Committee has the responsibility of communicating the quality manual with its accompanying performance objectives, processes, validation, and monitoring systems to the organization. This is accomplished through a series of board and cross-functional employee meetings, by written and electronic materials, and through flow charts and forms pertaining to the processes. Management also developed written procedures and processes for

- Satisfying customer complaints and
- Maintaining an ongoing Quality Committee.

The Quality Committee is composed of cross-functional employees appointed for 1- to 2-year terms by management. The committee

- Investigates and solves reported service and process problems,
- Identifies the underlying cause of nonconformities,
- Makes sure corrective actions are carried out,
- Keeps a record of corrective actions, and
- Follows up on corrective actions.

PERFORMANCE MEASURES, RESULTS, AND LEARNING EXPERIENCES

Once the QMS was fully implemented in March of 2000, the company's QMS Task Force conducted an internal audit to determine conformity and the effectiveness of implementation. Audit results were reported and recorded and follow-up actions were verified.

The 2001 Customer Satisfaction tracking survey showed an increase in both overall customer satisfaction with service and specifically an increase in satisfaction with the level of service disruptions and the handling of inquiries about billing concerns. Reducing service disruptions and customer complaints created cost efficiencies. Market share performance measures also showed positive results. An employee survey was conducted as a benchmark measure of satisfaction with the QMS process.

Based on the internal audit results, the Executive Committee contracted for an independent audit by an ISO 9000:2000 certified firm. This audit was conducted in the fall of 2001, and the company was certified as meeting ISO 9000:2000 standards. The standards require the company to collect information on the continuous functioning of the QMS. Information that must be collected and analyzed on a continuing basis relates to

- Customer satisfaction,
- Meeting performance objectives and service requirements, and
- Process characteristics and trends.

Using a quality policy, quality and performance objectives, quality manuals, audit results, and management reviews can improve customer satisfaction, market share, cost efficiencies, and revenue. When problems occur, analyzing and fixing the underlying process responsible leads to results.

PERFORMANCE MEASURES IMPLEMENTED

- Overall customer satisfaction with service and with level of service disruptions and handling of billing inquiries (10-point scale).
- Number of customer billing inquiries and number of customer billing complaints.
- Number of service disruptions.
- Trends in the number of customers.
- Costs of service disruptions and handling customer billing inquiries.
- Overall profitability values.

— 4 —

DEVELOPING A PERFORMANCE-MEASUREMENT PROGRAM

INTRODUCTION

This chapter is intended to provide transit systems with "hands on" assistance in developing performance-measurement programs or improving existing ones. The information presented is based upon a comprehensive literature review, a survey of more than twenty transit systems, and the research team's experience working with various transit systems throughout the country.

Implementing and updating a performance-measurement program is an iterative process.

Eight main steps are involved in establishing or refining performance-measurement programs. These steps are, in order,

1. Define goals and objectives;
2. Generate management support;
3. Identify internal users, stakeholders, and constraints;
4. Select performance measures and develop consensus;
5. Test and implement the program;
6. Monitor and report performance;
7. Integrate results into agency decision-making; and
8. Review and update the program.

Figure 4 illustrates the process of setting up a performance-measurement program. None of the steps in this process should be viewed in isolation from the others, because there is considerable overlap between them. In fact, the outcomes from virtually all of these steps will influence the others and will play a significant role in determining the program's overall level of success. Agencies should integrate these steps with each other and develop simple feedback loops designed to improve the effectiveness of the performance-measurement program. For instance, if a transit system encounters problems in a particular phase of the pilot data collection effort, there should be a feedback loop that directs the agency back to selecting performance measures that can be supported by the system's data collection capabilities.

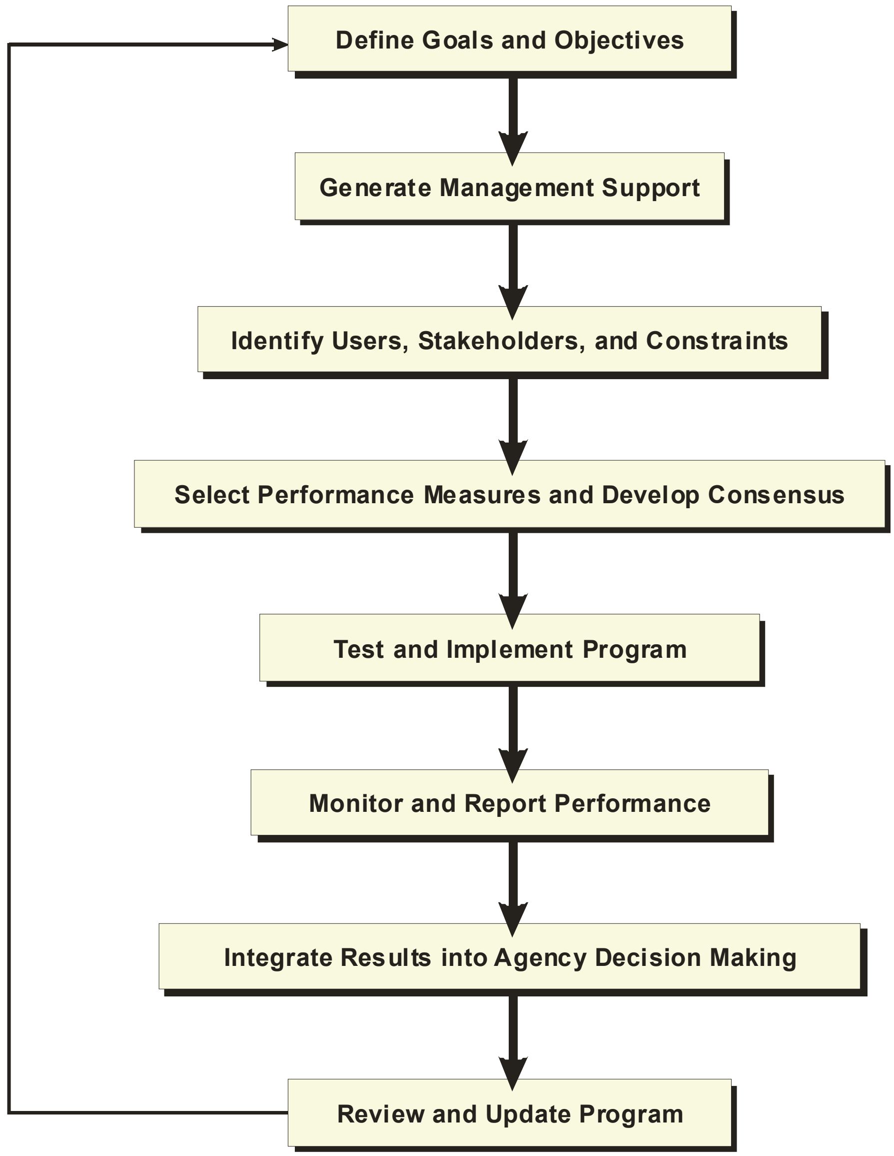


Figure 4. General Approach for Developing a Performance-Measurement Program

CHAPTER ORGANIZATION

The majority of this chapter covers the basic steps outlined in Figure 4, which are applicable to all agencies. *General demand-responsive*, *ADA paratransit*, and *contracted services* of all types require special consideration; specific issues related to these services are discussed following the basic process.

This chapter also presents recommended core sets of performance measures for fixed-route and demand-responsive services and ends with an example of how the process works.

STEP 1. DEFINE GOALS AND OBJECTIVES

THINGS TO DO

- Develop or update a set of agency goals and objectives.
- Include customer and community input when developing goals.
- Select an initial set of goals without worrying about potential measurement issues.
- Revisit the performance-measurement program each time the agency goals are updated.

DEVELOPING A NEW PERFORMANCE-MEASUREMENT PROGRAM

A successful performance-measurement program is integrated with the organization's goals and objectives.

The first step in any project should always address the "Why are we doing this?" question. Developing a performance-measurement program is no different.

An agency's first step should be to define its goals and objectives. If a performance-measurement program is not well integrated with the agency's goals and objectives, the program will be ineffective in performing its core function: *measuring the system's ability to achieve its goals and objectives.* Consequently, it is of paramount importance that a transit property establish clearly defined goals and objectives prior to developing its performance-measurement program.

Different goals and objectives may relate to the different user points-of-view described in Chapter 2.

There are many different types of goals and objectives that may be adopted by a transit property. Some transit agencies have adopted product-oriented goals which focus on meeting the needs and expectations of their passengers. Other agencies have remained with the more traditional process-oriented goals and objectives that evaluate the internal efficiency of the agency—how well the agency is able to utilize its resources in providing transit service.

A customer- and community-focused performance-measurement program should include input from external stakeholders when developing goals and objectives.

When developing a performance-measurement program, transit agencies should keep in mind the program's intended users and audience. A program that is intended to assess how well an agency serves its customers must account for those customers' needs and expectations when the program's goals and objectives are established. The best way to accomplish this is to incorporate customer and community input into the goal-selection process. Means of accomplishing this include

- Identifying key customer issues through a customer satisfaction survey,
- Working with an established citizens advisory committee,
- Convening a focus group with representatives of different transit stakeholders, and
- Holding public meetings to gather community input.

The important consideration here is that an agency can develop goals and objectives that it *thinks* relate to its customers' needs and expectations, but that turn out to be quite different from what its customers *actually* want. A program based on the first situation may do an excellent job of measuring the agency's goals and objectives, but any actions taken to improve performance will only accidentally result in any increase in customer satisfaction or ridership. In contrast, actions taken to improve service that are identified through a program designed around the second situation will be more likely to address issues important to customers and the community, and thus will be more likely to improve customer satisfaction and ridership. The European Union case study illustrates these issues.

Goals and objectives must be measurable, but do not let potential measurement issues constrain the selection of an initial set of goals and objectives.

How easily goals and objectives can be measured is considered in Step 4.

Regardless of the type of goal or objective, it must be measurable; otherwise, the agency has no means of evaluating its progress in achieving a given goal or objective. In general, just about any goal or objective can be measured; usually, the real issue is how easily it can be measured. This issue is considered during Step 4; it is important not to let potential measurement issues affect the selection of goals and objectives at this point in the process.

Updating an Existing Program

The performance-measurement program should be revisited each time an agency updates its goals and objectives.

As part of their planning process, transit agencies typically reassess their goals and objectives every five years or so. This is a worthwhile task, as it provides agencies with the opportunity to reconsider their priorities and reorganize their goals and objectives accordingly. As management and operating conditions change, transit agencies will generally want to adjust the system goals and objectives to ensure that they are still reflective of the community and agency priorities.

It is important that transit agencies also take this opportunity to review the performance-measurement program that was established in concert with the original goals and objectives. This process involves the same steps used to develop a performance-measurement program the first time. Even if only one or two goals change, it is important also to review whether other aspects of the program should be changed as well. For example, resource constraints that prevented an "ideal" measure from being used previously may have been removed. How results are reported could also be reviewed at this time.

EXAMPLES OF GOAL-SETTING

LIVERMORE, CALIFORNIA

The Livermore Amador Valley Transit Authority (LAVTA) is a small transit property that does a good job of establishing achievable goals and objectives that are within its means. Furthermore, the system prioritizes the achievement of its objectives by constantly monitoring its performance using nine separate performance standards that are tied directly to its goals and objectives. LAVTA reviews and updates its goals and objectives every 2 years as part of the completion of the Short Range Transit Plan. This continual review of its goals and objectives ensures that LAVTA maintains its vision and keeps pace with the constantly changing transportation needs of its community. The only weak link in the whole process is that LAVTA does not complete the final step of revising its performance measures to match the system's new goals and objectives. This is a critical final step, as otherwise performance measures continue to monitor an agency's original goals and objectives rather than its current ones.

CHICAGO, ILLINOIS

Most agencies simply want a performance-measurement program that is capable of evaluating an agency's ability to achieve its goals and objectives. However, there are exceptions to this rule. The Regional Transportation Authority (RTA) was created in 1974 to oversee transit service planning for the Chicago metropolitan area. As part of this charter, RTA created an extensive service standard and performance-measurement program to evaluate all transit services operated throughout the region.

When RTA's mission changed to coordinating transit funding in the 1990s, the performance-measurement reporting system was terminated. However, there has been renewed interest at RTA in developing a consolidated regional performance-measurement system for the Chicago area that would evaluate the three major transit providers in the area, CTA (urban bus and rail), Pace (suburban bus), and METRA (commuter rail). To this end, RTA has begun publishing annual peer review reports evaluating these three transit providers with one another and with selected peer agencies throughout the U.S. These reports are intended to provide RTA with a tool to evaluate all Chicago transit services across modes and to make an overall quality of service assessment on a regional and subregional level. This process should also lead to potential service recommendations.

SAN DIEGO, CALIFORNIA

Like the RTA in Chicago, the San Diego Association of Governments (SANDAG) is a regional agency responsible for transportation planning. SANDAG works closely with the Metropolitan Transit Development Board (MTDB) in preparing the regional transportation plan and transportation improvement program for the San Diego area. In the past, SANDAG has incorporated MTDB projects without questioning whether they were consistent with SANDAG's goals and objectives for growth in the region. Now, however, a series of transit performance measures is being used to assess the impact of transit capital projects in the 2030 Regional Transportation Plan (RTP) and to prioritize these projects. The program includes measures in the following areas:

- *Serving Commute Needs*—percentage of route on a roadway operating at LOS "E" or "F" in 2020, subregional area (SRA) employment as percentage of highest SRA employment, average route speed, morning and afternoon peak period ridership (considered separately), and morning and afternoon peak period ridership per service mile;
- *Serving Transit-supportive Corridors*—average population per square mile within ½ mile of stations, average employment per square mile within ¼ mile of stations, number of non-employment major activity centers within ½ mile of stations, midday and evening ridership, and midday and evening ridership per service mile;
- *Developing Network Integration*—number of other Yellow and Red Car (serving medium- and long-distance trips) transit routes connected to and number of transferring passengers by service mile; and
- *Cost-effectiveness*—subsidy per passenger mile.

Additional project-level performance measures include estimates of operating and capital costs. Future criteria to be addressed include transit service coverage and geographic balance of projects.

SANDAG does not get involved with MTDB's application of transit performance measures and service standards related to assessing current transit route and system operating performance. SANDAG's performance measures deal with broader "quality of life" issues and are designed to provide the agency with valuable feedback on whether MTDB projects are consistent with SANDAG's overarching goals and objectives.

STEP 2. GENERATE MANAGEMENT SUPPORT

THINGS TO DO

- Educate the board of directors and senior management regarding the value of a performance-measurement program.
- Create a limited number of aggregate performance measures that are easily understood and representative of the transit system's performance in key functional areas.
- Provide periodic performance reports to senior management.
- Provide senior management and board directors with the opportunity to shape the development of the performance-measurement program.

DEVELOPING A NEW PERFORMANCE-MEASUREMENT PROGRAM

Once the overall goals and objectives have been determined, transit systems are well advised to make sure that senior management is "on board" with the implementation of the performance-measurement program. The critical link in performance-measurement programs is identifying corrective action to improve a system's future performance. However, this link will not be in place if a transit system's senior management does not understand, stay involved, or support the program.

Regardless of the overall quality of a system's performance-measurement program, it will be of marginal value if the transit system's management does not support it.

As a means of ensuring complete management "buy in," transit systems should prioritize the four action items listed above under the *Things to Do* heading. These steps are particularly important for a transit system attempting to set up a performance-measurement program for the first time.

By educating board members and senior management about the value of a performance-measurement program, transit systems build the foundation for a successful program. Without this foundation of understanding, key decision-makers may consider performance measurement to be just another layer of government bureaucracy. Presenting examples of performance-measurement success stories from peer transit agencies is a good technique to illustrate the value of an effective performance-measurement program. It is also important for transit staff to discuss the data collection and analysis requirements of the program with senior management and board members so that all parties are aware of the level of effort required for full program implementation.

Transit systems should develop aggregate performance indicators to reduce the amount of information that decision-makers must process to understand the key trends in the system's overall performance. For instance, a single indicator could be developed to represent a system's service effectiveness that compared service consumption (ridership) with service outputs (hours, miles, etc.). As such, the aggregate indicators would be a function of several more detailed performance indicators. It is expected that the aggregate indicators would provide meaningful information to decision-makers in a more digestible format.

Aggregate performance indicators should be designed to supplement the collection of more extensive performance indicators, not replace them.

Step 6 provides additional detail on performance-measurement reporting.

By providing periodic performance reports to senior management and the system's board of directors, the transit system should be able to keep the decision-makers informed of trends in the system's operating performance. If designed properly, management will grow to rely upon these reports as a critical input to the decision-making process. Transit systems that do not provide regular performance reports to their board of directors may erode the support among the decision-makers for the performance-measurement program.

Lastly, transit systems should always provide senior management and board members with the opportunity to shape the development of the performance-measurement program in all its permutations. Feedback should be collected on an ongoing basis on all aspects of the performance-measurement program. However, transit systems should pay particular attention to soliciting feedback from board members and senior management as specific measures are being reviewed and updated to improve the overall performance-measurement program. This process should provide the transit system's decision-makers with a stronger sense of ownership regarding the performance-measurement program.

EXAMPLES OF GENERATING MANAGEMENT SUPPORT

CHAMPAIGN-URBANA, ILLINOIS

The Champaign-Urbana Mass Transit District (CUMTD) has made a concerted effort to involve and empower its management in the performance-measurement program by involving these individuals in its development and ongoing review. In this capacity, senior management and the board of directors meet every 3 to 5 years to review the system's performance measures, ensure that the program is consistent with the system's goals and objectives, and revisit the performance thresholds at which corrective action is required. CUMTD's board of directors have also come to rely upon the performance reports as a critical input into their decision-making responsibilities. This approval and review process exposes the performance-measurement program to further scrutiny and also ensures consensus among CUMTD's governing board.

NASHVILLE, TENNESSEE

The Nashville Metro Transit Authority (NMTA) also represents an excellent example of a system that has been able to generate management support for its performance-measurement program. As the first agenda item at monthly meetings, NMTA's board reviews performance measurement reports prepared by the system's staff. This review process provides board members with constant updates on the state of the transit system and has illustrated to the NMTA board the importance of the performance-measurement program. The review process has been in place since NMTA adopted its performance-measurement program in 1985.

STEP 3. IDENTIFY USERS, STAKEHOLDERS, AND CONSTRAINTS

THINGS TO DO

- Determine who will be utilizing the performance-measurement program on a regular and periodic basis.
- Evaluate existing and expected human, financial, and technical resources for the performance-measurement program.

IDENTIFYING INTERNAL USERS

The characteristics of the performance-measurement program will vary substantially depending upon the intended audience. For instance, a performance-measurement program that is designed for internal system evaluation and monitoring should vary significantly from a program developed by the marketing department to use in promotional campaigns for the transit system. In general, performance measures intended for use by the general public should be relatively simple and easy to understand; whereas, performance measures intended for internal system evaluation can be more complex, involved, and comprehensive.

Become familiar with the audience and available resources, because these two factors will weigh heavily upon the type of performance-measurement program developed.

EXAMPLES OF IDENTIFYING USERS

NEW YORK, NEW YORK

MTA-NYCT has numerous performance indicators and performance-measurement programs in place. Furthermore, MTA-NYCT recognizes that the performance measures should be tailored for the many different user groups and audiences involved in making decisions about the transit system. As such, the transit system has adopted a number of different performance-measurement programs that have been designed to serve each of these decision-making entities. Following is a summary of MTA-NYCT's performance-measurement programs:

- *Department-level indicators*: These are self-reported to the president or board and used for internal purposes.
- *Agency-wide indicators,* including safety and security indicators: These have been generated for many years.
- *Subway and bus service indicators*: There are two customer-oriented indicators reported on a quarterly basis by Operations Planning to the president and board. Established in 1995, these indicators are used by operating departments to (1) initiate specific programs (e.g.,

road dispatchers) addressing problem areas and (2) assess the success of specific programs to improve service.

- *Passenger environment survey (PES):* A collection of numerous indicators measuring the passenger environment of subway cars, stations, and buses. These indicators are reported on a quarterly basis by Operations Planning to the president and board. The PES began in the mid-1980s and was significantly restructured in 1995 and 2000 to better reflect customer perceptions. PES indicators are reported to the relevant operating department, which decides whether steps should be taken to address problematic areas.
- *Market research*: Market share panels started in 1995. This measure is reported by MTA-NYCT on a quarterly basis. An annual Citywide Survey of attitudes of bus and subway service is also performed.
- *Financial reports*: Financial and ridership reports have been generated for many years and are presented to the board. These reports compare budget and actual financial results on a year-to-date basis, and compare weekday and weekend subway and bus ridership on a monthly and year-to-date versus the previous year basis.
- *Capital program status*: MTA-NYCT reports key capital project milestones (planned versus achieved) in dollars and on a percentage basis. The capital program status reports have been ongoing for many years.
- *Departmental Goals Report* and *Strategic Business Plan*: These are considered the most important indicators. The departmental goals report, established in the mid-1980s, had a hiatus of several years but was re-established in 1997 and is an internal document with about 75 indicators. The Strategic Business Plan has been reported to the State since 1988 and contains 14 indicators.

OSHKOSH, WISCONSIN

Oshkosh Transit is a small urban transit system located in east central Wisconsin. Fixed-route service is provided within Oshkosh and between Oshkosh and Neenah. Oshkosh Transit also provides ADA paratransit service and coordinates additional demand-responsive service within Winnebago County. Oshkosh Transit has a performance-measurement program and reports measures from this program to the following four groups:

1. The Wisconsin Department of Transportation (WISDOT), which provides the largest percentage of operating revenue within Oshkosh's budget;
2. The Oshkosh City Council (because Oshkosh Transit is part of a municipal department for the City of Oshkosh);
3. Citizen groups; and
4. Internal staff.

Oshkosh Transit also recognizes that each of these groups is distinctly different from one another and has developed separate performance measurement reports that are submitted to each group. For instance, reports submitted to the City Council and WISDOT include the following measures:

- Annual ridership (by mode, route, and contract);
- Passengers per mile;
- Passengers per hour;
- Cost per passenger;
- Farebox recovery ratio;
- Cost per vehicle hour;
- Cost per vehicle mile; and
- Revenue passengers per capita.

While some of these measures may be included in reports to local citizen groups, Oshkosh Transit believes that other measures, such as community-based indicators, may be most appropriate for this audience. The community-related performance measures are reported on an annual basis and include the following:

- On-time performance;
- Passengers per capita;
- Complaints and compliments;
- Jobs generated by transit; and
- Local economic benefits.

IDENTIFYING STAFF, FINANCIAL, AND TECHNICAL CONSTRAINTS

The two examples provided above illustrate that the operating characteristics of a particular transit property play a huge role in shaping the nature of the system's performance-measurement program. A large urban transit system will have more resources available than will a small, rural transit property. Consequently, a transit system should consider all relevant system constraints when designing its performance-measurement program. An overly ambitious performance-measurement program is not advised, particularly for smaller agencies, as it will more than likely fall short of expectations and fail to provide the system with particularly valuable information. Instead, agencies should consider developing more realistic performance-measurement programs that are more likely to be useful and achievable. If necessary, an agency can revisit and expand upon the existing performance-measurement program to include additional performance standards or categories.

When developing a new performance-measurement program, start small and build upon the program as the agency becomes more experienced in performance measurement.

Chapter 5 provides descriptions of various resources available to help measure performance and the amount of effort required to use those resources. The individual measure descriptions in Chapter 6 also provide information on the level of effort required to use a given measure.

EXAMPLES OF IDENTIFYING CONSTRAINTS

CHICAGO, ILLINOIS

The Chicago Transit Authority (CTA) has plans to incorporate various ITS technologies in its data collection efforts. These plans are in place because the agency realizes that it does not have access to sufficient information to effectively monitor and improve system performance. CTA indicated that staff are currently able to monitor performance standards in the maintenance categories much more effectively than they can more traditional performance measures such as *on-time performance* or *passengers per mile*. This is not particularly surprising, considering CTA has direct control over its maintenance operations and is able to monitor issues such as how long a rail car is out of service for repair. CTA expects that various technological improvements will reduce the information constraints that have been hampering elements of its performance-measurement program.

ALBANY, NEW YORK

The Capital District Transportation Authority (CDTA) in Albany, New York, is also in the process of implementing new technologies to improve its data collection capabilities. CDTA's biggest concern with its performance-measurement program has been data integrity. The transit system has struggled to implement data collection systems that are not prone to human error. Bus operators had to be trained to use and record farebox information correctly, yet CDTA continued to have issues with its data integrity. Consequently, automatic passenger counter (APC) equipment has been installed on some of CDTA's buses to improve the quality of the system's ridership data. Automatic vehicle location (AVL) equipment will also be installed in the near future on many of CDTA's buses. This should improve CDTA's capability to collect schedule adherence and other performance statistics on a more system-wide basis.

STEP 4. SELECT PERFORMANCE MEASURES AND DEVELOP CONSENSUS

THINGS TO DO

- Determine performance measurement categories.
- Review performance measures utilized throughout the industry.
- Consider data collection constraints, as was discussed in Step 3.
- Select performance measures.
- Develop targets or standards for the selected measures.
- Develop consensus among the key stakeholders involved.

SELECTING PERFORMANCE MEASURES

Prior to selecting specific performance measures, it is recommended that transit systems establish general, overarching categories for their performance-measurement programs. These categories should be directly linked with the system's goals and objectives. Within these categories, specific performance measures should be developed to actually track the system's performance over time. The Guidebook's recommended core measures and the performance measure menus and summaries can be used as a basis for developing categories and individual measures. The selection menus, in particular, can be used to match goals and objectives with individual measures and to compare data and resource requirements between measures.

If the data are not available or too difficult to collect, the performance measures become useless and obsolete. Conversely, too much data can also present an obstacle if the agency is unable to analyze the data in a timely manner.

For a variety of reasons, transit systems will not always be able to implement the ideal performance-measurement program immediately. Under these circumstances, it is recommended that interim measures be developed and implemented to ensure that the agency is able to monitor its performance in some manner. Meanwhile, the transit system should continue to work at putting systems in place for the eventual implementation of the ideal performance-measurement program. While interim measures should evaluate key performance categories such as cost-efficiency, cost-effectiveness, quality of service, and service effectiveness, the measures should be relatively simple and fairly easy to calculate, since they will be in effect only for a finite time period.

If an agency is unable to identify a suitable interim measure for a goal and does not have the resources available to use an ideal measure, it should reconsider using that goal.

EXAMPLES OF SELECTING MEASURES AND SETTING STANDARDS

LIVERMORE, CALIFORNIA

The Livermore Amador Valley Transit Authority (LAVTA) conducted a thorough examination of the performance measures used by the industry before setting up its program in 1998. Based on this review, LAVTA selected nine performance measures intended to measure the system's ability to provide reliable, economical, efficient, and safe transit services. LAVTA also established target values for each of these performance standards that allow the system to evaluate its performance in each fiscal year as either "meeting the standard" or "not meeting the standard." Table 9 presents the fixed-route performance standards and objectives for the LAVTA fixed-route network.

Table 9. LAVTA Fixed-Route Performance Standards

Objective	Performance Standard	FY 1999/2000 Performance
Attainment of a minimum threshold rate for farebox recovery	14%	17.8% Exceeds standard.
Operate service in a manner that will maximize productivity	13.0 passengers per hour	16.3 passengers per hour Exceeds standard.
Operate service in a manner that will maximize system efficiency	Annual increase in operating cost per vehicle service hour should not exceed the CPI for the region	CPI: 5.8%* Increase in op. cost/hour: 7.5% Did not meet standard.
Operate service in a manner that will maximize system effectiveness through a provision of reliable transit service	95% of scheduled departures on-time or up to 5 minutes late	Did not meet standard in 8 of last 12 months.
	0% of scheduled departures and 0% of missed scheduled trips	Meets standard.
	7,000 vehicle miles between road calls	Meets standard.
Operate service safely	50,000 to 70,000 vehicle miles between traffic accidents	Meets standard.
	1 passenger injury per 100,000 passenger boardings	Meets standard.
	100% of preventive maintenance inspections completed within 10% of scheduled mileage	Did not meet standard (based upon an analysis of the maintenance records of a random sample of vehicles).

*Bureau of Labor Statistics data for the San Francisco Bay Area, April 2000-April 2001.

DENVER, COLORADO

The Regional Transportation District (RTD) in Denver has a three-tiered performance-measurement system, consisting of Service Standards, a Quarterly Progress Report, and an Annual Report. Each report contains different performance measures that are considered most appropriate for evaluating different aspects of RTD's performance. Key economic performance measures are *subsidy per passenger* and *passengers per mile*. The Quarterly Progress Report addresses *complaints*, *schedule adherence*, and safety (*vehicle accident ratio per 100,000 miles traveled*). Service standards and economic performance measures are identified for seven classes of service, including the following:

- Local-CBD,
- Local-Urban,
- Local-Suburban,
- Express,
- Regional,
- Demand-Responsive, and
- skyRide (service to Denver International Airport).

Service standards within each class of service are updated every 3 years as operating conditions change throughout the region. In addition to service standards and economic performance measures, RTD also measures "softer" indicators relating to the transit system's customer service performance. RTD collects this information through annual on-board customer surveys and bi-annual telephone surveys of the general population.

MIAMI, FLORIDA

Miami-Dade Transit Authority (MDTA) in Miami, Florida, incorporates customer satisfaction surveying into the evaluation of the transit system's success. For instance, a research firm conducts a "tracking" survey of 2,000 residents in Miami-Dade County every 3 years to assess their personal and travel characteristics and attitudes about MDTA service. The following items are addressed in this survey:

- Patterns of general ridership and commuting behavior;
- Changes in incidence of ridership among bus riders, rail riders, potential riders, and absolute non-riders;
- Profile of bus/rail/dual transit riders;
- Profile of potential riders and non-riders; and
- Overall attitudes on service (e.g., safety and types of required improvements).

This type of approach would likely not work for all transit agencies, due to privacy concerns and/or resource constraints. However, this approach could prove to be quite valuable in assisting transit agencies to better understand the travel patterns of the populations in their service areas.

SYDNEY, AUSTRALIA

When State Transit in Sydney, Australia, developed its performance-measurement program in 1997, it made a deliberate effort to match the measures used in the program to its objectives. Each objective has several performance measures associated with it; some require regular monitoring, while others can be answered on a yes/no basis. For example, the following measures are associated with State Transit's objective of providing reliable service:

- On-time performance in normal traffic conditions (no more than 5 minutes late),
- No early running,
- Mechanical failures preventable through regular maintenance, and
- Road calls per 100,000 kilometers.

In contrast, the measures of passenger safety and security are developed in the form of design standards. These standards seek to ensure a safe and secure environment through design, rather than measure the level of safety and security being provided:

- All buses fitted with closed-circuit television units.
- All buses in radio contact with the control center.
- Non-slip floors on all buses.

The Sydney case study provides additional examples of measures that are linked to the agency's objectives.

DEVELOP CONSENSUS

While it may not be as important to have broad community support for a performance-measurement program, compared with having support for a transit system's goals and objectives, a transit agency should make a concerted effort to develop consensus on the performance-measurement program among the key stakeholders involved. For most transit agencies, key stakeholders include the following: transit agency staff, the board of directors, involved decision-makers, and public officials. Ideally, a transit agency would also hold a public forum to provide the general public with an opportunity to provide feedback on the performance-measurement program.

Figure 5 presents some critical issues to consider in the consensus building process. It is important to mention that there is no equation or uniform approach to developing consensus, since transit agencies are quite different from one another. Nonetheless, there are certain guiding principles that should assist transit agencies in achieving consensus regarding their performance-measurement programs.

Figure 5. Developing Consensus

Just as it is important to achieve consensus during the development stage of a performance-measurement program, it is equally important to maintain this consensus over time. As such, the agency should encourage internal and external scrutiny of its performance-measurement program as a means of ensuring the continued value to the transit system. One technique for maintaining consensus over time is to require an update of the performance measures on a regular basis, such as every year or two. The update will provide all interested parties with the opportunity to evaluate and propose changes to any and all facets of the performance-measurement program.

Refer to Step 8 (Review and Update Program) of the performance measurement process for more details.

Examples of Developing Consensus

New York, New York

MTA-NYCT prioritizes consensus-building for its performance-measurement programs and has developed various processes for re-evaluating each program over time. The following is a brief list of some of the major issues that MTA-NYCT considers as it re-evaluates its performance-measurement programs:

- *Prioritizing indicators* (since there are so many of them): The question becomes, which ones should be reported to the president and the board?
- *Objectivity*: To ensure objectivity as well as a customer-oriented perspective, Operations Planning was given the responsibility of collecting and reporting bus and subway indicators.
- *Customer focus*: Changes to indicators reported by Operations Planning are made to better reflect the customer experience (e.g., revisions to the bus and subway indicators in early 2001 and PES indicators in 1995 and 2000).
- *Technology*: Because manual data collection and reporting result in a long time lag between the actual results and reporting, automated data collection and on-line reporting alleviate this lag (e.g., the Department of Buses on-line indicator report).

As a means of developing consensus in each of these categories, MTA-NYCT has a number of reports that the system updates on a fairly regular basis to ensure that all performance-measurement programs are still doing their jobs. One of these documents is the agency's 2001-2005 Strategic Business Plan that was published in December 2000. The three goals listed in this document pertain to the MTA and its component agencies, including MTA-NYCT. These goals are

- Improve safety for employees and customers,
- Improve customer satisfaction, and
- Improve cost-effectiveness.

There are inter-agency strategies and tactics (action plans) as well as agency-specific strategies and tactics to address these goals. Each agency also has indicators to assess its progress toward each of the goals. This process ensures that (at least in concept) each indicator is an important part of goal assessment and that the agency is engaging in activities which will lead to the achievement of each goal.

STEP 5. TEST AND IMPLEMENT THE PROGRAM

THINGS TO DO

- Develop a pilot project for the performance-measurement program.
- Test the agency's data collection and analysis capabilities through the pilot project. Develop alternative measures if needed.
- Assign program responsibilities to transit staff.
- Implement the performance-measurement program.
- Periodically review technological developments that may improve data collection capabilities.

TESTING AND IMPLEMENTING THE PROGRAM

After transit agencies go through much planning and program development, the implementation of this step represents the point where the performance-measurement program is put into action. Agencies are advised to develop a pilot project for initial implementation as a means of testing the program objectives and identifying potential pitfalls in the design and implementation of the performance-measurement program.

Step 4 suggested that performance standards are only as good as the agency's data collection capabilities. This is an important point to consider in this step as well, since a transit agency's ability to successfully test and implement its performance-measurement program will be largely dependent upon its data collection capabilities. Additionally, it is important that transit agencies continue to revisit their data analysis procedures as technological improvements provide systems with greater access to information. Regardless of various technological improvements, agencies need to have sound data collection and analysis procedures and methodologies in place in order to successfully monitor performance.

Many of the transit systems interviewed for this project indicated that technological improvements have substantially improved their ability to collect information and monitor system-wide performance.

In order to implement an effective performance-measurement program, various components of the program must be assigned to specific staff members. This ensures that the performance-measurement program will become a priority of the system and will be relied upon by staff members in their decision-making process.

Figure 6 depicts the feedback loop associated with the three main responsibilities in implementing a performance-measurement program: data collection, data analysis, and data reporting. Transit agencies should be aware that data processing is an ongoing component of performance measurement and steps should be made to improve data processing whenever possible.

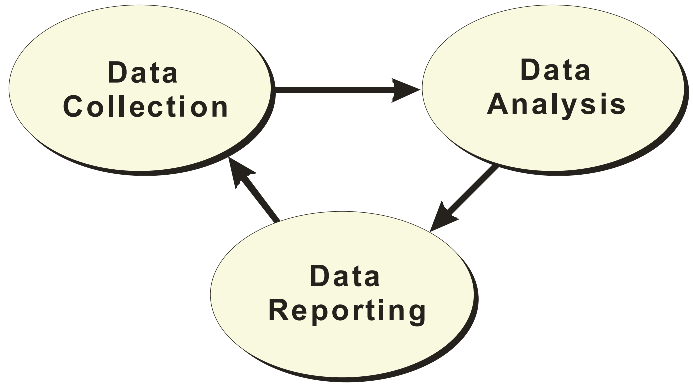


Figure 6. The Three Primary Performance Measurement Responsibilities

EXAMPLES OF TESTING AND IMPLEMENTING PROGRAMS

ALBANY, NEW YORK

At the Capital District Transportation Authority (CDTA) in Albany, New York, the planning staff implemented the performance-measurement program, but the information technology group handles the data collection efforts. The group obtains the data from the field from bus operators, using farebox information. The biggest concern has been data integrity. Bus operators had to be trained to use and input farebox information correctly.

PORTLAND, OREGON

The Tri-County Metropolitan Transportation District of Oregon (TriMet) conducts telephone surveys of the general public approximately twice a year. TriMet refers to this survey effort as the Attitude and Awareness Survey and has developed six key indicators for which the system collects information. These indicators relate to issues such as TriMet's job approval rating, light rail expansion, and the system's market share among adults age 16 and older.

By asking survey respondents many of the same questions year after year, TriMet is able to get a sense of how public opinion changes over time. For example, TriMet's most recent survey effort in August 2001 revealed that public support for the system's light rail network had increased anywhere from 5 to 14% depending upon the rail line in question. TriMet can utilize this information to influence the policy-making process and shape the direction in which the agency moves. It is also interesting to note that TriMet utilizes automatic vehicle location (AVL) systems and automatic passenger counters (APC) to monitor on-time performance and daily ridership figures. In fact, TriMet staff indicated that they are frequently in a state of information overload, since they are not accustomed to having access to so much information.

CHICAGO, ILLINOIS

The rail division of the Chicago Transit Authority (CTA) has been practicing performance measurement since 1992. In recent years, this performance-measurement program has been utilized as an employee incentive program tied to system performance. CTA employee contracts provide financial rewards to particular employees when the transit system performs well. Senior management believes that this approach to implementing the performance-measurement program has translated to improved employee performance and morale.

LIVERMORE, CALIFORNIA

LAVTA uses a private operator for transit service provision. As part of the contractual arrangement with LAVTA, the operator is responsible for monthly performance reporting on a series of performance standards. There are various bonuses written into the contract rewarding the private operator for meeting or exceeding the target value for each performance measure. If the operator fails to meet the standard, the operator simply does not receive the bonus for that particular reporting period.

STEP 6. MONITOR AND REPORT PERFORMANCE

THINGS TO DO

- Establish a schedule for regular performance reporting.
- Consider system requirements, as these will affect the manner in which performance is monitored and reported.
- Monitor system performance at agreed-upon intervals.
- Check results for reasonableness.
- Develop a performance measure report format.

MONITORING AND REPORTING PERFORMANCE

Once a transit agency has implemented its performance-measurement program, the next step consists of monitoring and reporting upon the system's performance. Throughout the literature review and the transit agency interviews, one common theme among virtually all transit properties was regularly scheduled performance reporting. Some agencies conducted monthly reporting on their performance standards, and others preferred quarterly, semi-annual, or annual reporting.

The frequency of performance reporting will depend upon many factors, including system size, data collection capabilities, and staff resources.

Different audiences will require different report formats. Agency staff responsible for specific facets of performance will require more detailed information, while decision-makers and the public will require more general, but more comprehensive information. All audiences need to have information communicated in a way that is easy to understand for that audience. Chapter 5 provides examples of reporting techniques used by transit agencies.

EXAMPLES OF MONITORING AND REPORTING PERFORMANCE

NASHVILLE, TENNESSEE

Every month, Nashville Metropolitan Transit Authority (NMTA) conducts a ridership survey to monitor on-time performance, safety, and system cleanliness. Although it takes additional time and resources to monitor and report on system performance every month, NMTA is rarely surprised by their performance results because of the regular frequency of data collection and performance monitoring. Having access to such timely information assists NMTA in making responsive service adjustments to meet the changing needs of its passengers.

LOS ANGELES, CALIFORNIA

The Los Angeles County MTA (LACMTA) indicated that the primary obstacle to regular performance-measurement reporting was data acquisition. The agency had internal issues assembling the data gathered by different internal departments and experienced significant delays before regular data collection and monthly reporting was established. Before these regular weekly and monthly reports had been established, performance reports were intermittent and were not consistently disseminated to the same individuals, which made it difficult to incorporate this information into the decision-making process. LACMTA considers regular performance reporting to be tremendously successful and critical to the decision-making process.

SAN DIEGO, CALIFORNIA

The Metropolitan Transit Development Board (MTDB) in San Diego, California, is a special district governed by a 15-member board of directors responsible for overseeing multiple transit operators in the metropolitan area. MTDB is empowered by state legislation to plan, construct, and operate mass transit guideways. It serves as the policy-setting agency for public transportation in the region. MDTB uses a three-tiered performance measure program, consisting of the following reports:

- Quarterly Operations Report (also Annual Report), prepared by MTDB Service Planning;
- Quarterly Budget Report, prepared by MTDB Finance; and
- Annual Route Monitoring Report, prepared by MTDB Service Planning.

MTDB is currently revamping its performance-measurement system to combine these programs into a single reporting system.

The following indicators are used in the Quarterly Operations Report:

- Passengers per mile,
- Passengers per hour,
- Subsidy per passenger, and
- Cost per hour.

The performance indicator used for the Quarterly Budget Report is *budgeted versus actual costs* (monthly and quarterly, aggregated to an annual comparison). MTDB has experienced problems with not receiving data for this measure on time from the individual transit operators under the MTDB umbrella.

The following indicators are used for the Annual Route Monitoring Report:

- Passengers per mile,
- Passengers per hour,
- Passenger miles per seat mile, and
- Subsidy per passenger.

The Quarterly Operations Report and Quarterly Budget Report address system conditions, while the Annual Route Monitoring Report is route-specific. The Route Monitoring System separates routes by classes:

- Suburban feeder,
- Urban feeder,
- Line-haul,
- Crosstown,
- All-day express, and
- Premium express.

Each type of service performs differently. A single index score combining the four measures is developed for each route, applying equal weighting to each measure. Each route is then evaluated against the average in each category. All routes are ranked together, regardless of the type of service. Routes with less than 75% of the average score are then further assessed through a “route segmentation analysis,” which looks at route performance by different times of day and different days of the week.

As their names suggest, the two quarterly reports contain statistics measured quarterly, while the Route Monitoring Report reports measures annually. Data are provided from the transit operators under the MTDB umbrella:

- San Diego Transit,
- San Diego Trolley,
- National City Transit,
- Chula Vista Transit,
- MTDB Contract Services,
- North County Transit System,
- La Mesa Dial-a-Ride, and
- Complementary ADA Services.

Operators submit data on a form and send copies of the forms to MTDB and the San Diego Association of Governments (SANDAG) for processing. A web-based reporting form has recently been developed that allows operators to submit the form electronically. Passenger data are also requested by passenger type, when available.

All of the data collected have been found to be useful. The Quarterly Operations Report discusses why particular measure results have changed from one quarter to the next. The data are used in service planning, with service changes three times per year: in January, June, and September (coordinated with school openings and closures).

The California Transportation Development Act (TDA) requires annual reporting. TDA is the primary transit operating fund in California. This reporting requirement in the past has been more of a formality associated with grant compliance. In a previous annual assessment by MTDB auditors, the economic productivity reporting system was not considered adequate. MTDB is working on integrating its transit performance system with the

TDA reporting requirement, to create one reporting system. Current TDA reporting measures include

- Passengers per revenue mile,
- Passengers per revenue hour,
- Operating cost per passenger, and
- Farebox recovery ratio.

In general, MTDB staff are very positive about transit performance measurement and are looking forward to having a consolidated reporting system that meets state TDA requirements.

CHECKING RESULTS FOR REASONABLENESS

There are a number of ways that errors can creep into performance measure results, ranging from simple transcription errors as data are copied from manually written sheets into a computer, to user error in applying a particular kind of technology, to serious flaws in a data collection methodology. Because significant errors in reported results can lead to incorrect conclusions about system performance, wasted effort by the agency correcting problems that may not exist, and reduced user confidence in the entire performance-measurement program, it is important to check the results before they are reported and distributed.

Potential errors that can arise from data collection are discussed further in Chapter 5.

Simple techniques for checking the reasonableness of results include comparing current performance to past performance and comparing results to peer agencies.

Trend analysis is a useful, easy-to-apply tool for checking results. If the performance in an area changes significantly from the previous reporting period, or from the same period the previous year, and there is no obvious reason why performance should have changed, the data should be checked to ensure that an error has not occurred.

Peer group analysis is particularly useful when first starting to use a new measure: results that are significantly higher or lower than the peer agency results may indicate a fundamental problem with the data collection methodology.

STEP 7. INTEGRATE RESULTS INTO AGENCY DECISION-MAKING

THINGS TO DO

- Develop a preferred approach for result integration.
- Consider the desired frequency of system evaluation.
- Compare the performance results to the goals set for each measure.
- For measures not meeting their goals, identify action items for improving performance.
- For measures consistently exceeding their goals, consider increasing the target, if cost-effective to do so.

INTEGRATING RESULTS INTO AGENCY DECISION-MAKING

As was mentioned previously, transit agencies must have policies and procedures in place establishing how they will make adjustments to their service provision approach, based on the information collected through the performance-measurement program. In fact, this is quite possibly the most important step in the whole performance-measurement process.

After collecting, evaluating, and reporting the data from the performance-measurement program, transit agencies are faced with the question of what they should do to improve overall performance.

The performance measure standards developed during Step 4 form the basis for evaluating goal achievement. Goals not being met should be targeted to see if further action is needed. Goals that are consistently exceeded should be re-evaluated to see if they can be set higher. This evaluation should consider whether the benefits of the higher performance level would outweigh any costs associated with achieving that performance.

Without a clearly defined course of action for improving system performance, transit systems are sure to struggle with integrating the results from the performance-measurement program with the agency's decision-making process. While corrective action will vary from case to case, transit agencies with clearly defined target values integrated into the performance-measurement program are at a definite advantage over those without this additional layer of performance assessment.

Examples of Integrating Results into Decision-Making

Champaign-Urbana, Illinois

In their most recent strategic plan, CUMTD established a set of empirical averages for route performance upon which the agency's performance standards are based. For any route performing at 50% above or below the system average, CUMTD staff analyze the route data and make recommendations to improve route performance. This route-by-route analysis occurs on a quarterly basis.

Nashville, Tennessee

NMTA utilizes a similar approach to that of CUMTD to identify corrective action, except a route must be performing at or below 60% of the system average to be subject to review. NMTA implements service adjustments based upon this review process every 6 months.

Baltimore, Maryland

The Mass Transit Administration (MTA) in Baltimore, Maryland, rates its commuter bus services as either "successful," "acceptable," or "problem" routes, with the score based on an average of four performance measures. The following thresholds are used to distinguish between the ratings.

Successful:

- Greater than 3.4 boardings per mile,
- Greater than 40 boardings per trip,
- Greater than 50% farebox recovery ratio, and
- Less than $0.60 subsidy per boarding.

Problem:

- Fewer than 1.6 boardings per mile,
- Fewer than 20 boardings per trip,
- Less than 30% farebox recovery ratio, and
- Greater than $1.20 subsidy per boarding.

"Acceptable" consists of values between the listed values above. MTA evaluates route performance on a monthly basis and will monitor "problem" routes before implementing route changes designed to improve performance.

Regardless of the manner in which performance-measurement results are integrated into the decision-making process, one critical lesson is that information needs to be provided on a regular, ongoing basis to provide decision makers with timely information. The most effective means of ensuring that this occurs is to mandate monthly performance reports that are submitted and presented to a transit property's decision makers at regularly scheduled meetings.

Step 8. Review and Update the Program

Things to Do

- Periodically evaluate the performance-measurement program.
- Based upon the evaluation, make an assessment of whether an update is necessary.
- If an update is necessary, return to step 1 (define goals and objectives) and repeat all of the steps presented above.

Reviewing and Updating the Program

To maintain an effective performance-measurement program, transit agencies should periodically review the overall program performance. The frequency of these reviews will vary from agency to agency, but it is recommended that these reviews be completed every 5 to 10 years.

The key concept here is that a transit agency must continue to evaluate and revisit its performance-measurement program for the program to maintain its value to the agency.

It should be noted that many transit agencies do not have a formal process in place to review and update their performance-measurement programs. These agencies appear to subscribe to the “if it ain’t broke, don’t fix it” philosophy. This approach is fine as long as the agencies are capable of recognizing when their performance-measurement programs are outdated and due for review. To avoid this problem, transit agencies are advised to incorporate the performance-measurement review process into the preparation of the system’s short-range planning studies that are completed every few years. This tactic will provide each transit agency with a regularly scheduled opportunity to evaluate the effectiveness of its performance-measurement program and to revise it as necessary.

Examples of Reviewing and Updating the Program

Chicago, Illinois

CTA’s performance measures are evaluated and updated on an annual basis. This evaluation includes a review of the system’s goals and objectives, as was recommended above. At present, CTA believes that its performance standards are a fairly accurate reflection of the system’s goals and objectives. CTA periodically eliminates some performance standards if staff believe that the measure is not meaningful or effective.

Portland, Oregon

TriMet has not substantially changed its performance-measurement program in over 12 years. TriMet has been pleased with the existing performance measures and has not considered it necessary to revamp the program. While it may not be necessary to make many significant changes to the performance-measurement program as was the case at TriMet, transit agencies should continue to monitor their programs to ensure that they are still serving the intended purposes.

SPECIAL CONSIDERATIONS

Transit service in most urban areas is primarily provided through fixed-route and fixed-guideway service. The large majority of service and expenses is dedicated to the provision of those services, which are used by the large majority of a system's riders. Therefore, performance measures tend to focus on the primary areas of service to ensure the best possible fit with the primary service provided. Additionally, as an industry, transit largely focuses upon developing and using measures primarily suited to the largest mode(s) of service in terms of ridership and costs.

However, by limiting the measurement program's focus, a standardized set of performance measures may fail to accurately and fully assess performance effectively across different modes of transit service. Developing a comprehensive guidebook for transit performance requires assessing performance in a variety of different transit modes, including fixed-guideway, fixed-route, and demand-responsive services. Performance measures and standards can be used to assess a transit agency based on measures of service efficiency, service effectiveness, and public transit's role within the community it serves.

Agencies are expected to strive to perform well and to increase the amount and quality of service they provide, while increasing the benefits that transit provides the citizens it serves. Superior transit service should lead to financial stability, improved service quality, and opportunities for service growth. Transit service must comply with existing laws such as the ADA, and meet as best as possible (within existing resources) the public transportation needs of its community.

Demand-responsive service in public transit usually involves advanced reservations and shared service and is provided in a substantially different manner than fixed-route service. Providing demand-responsive service will require different tasks and a different approach to service delivery. Additionally, in the case of ADA complementary paratransit, a substantial body of regulations acts as de facto performance measures and may require the development of measures to ensure compliance.

Demand-responsive service is somewhat different from other transit modes for several reasons:

- Civil rights requirements of ADA complementary paratransit service mandate many of the specific methods of transit service.
- Productivity limitations that exist in demand-responsive service limit or affect growth.

- Demand-responsive requires a significantly different service delivery approach, since individuals' trips must be scheduled and drivers' routes change constantly.
- Growth in demand often lacks economies of scale and results in significant financial stress for a transit agency, including limiting of demand-responsive service or reducing the levels in other service modes.

Providing practical and useful transit performance measurements and standards for demand-responsive service therefore requires an approach that recognizes the significant service differences that exist in demand-responsive and seeks a strategy consistent with those differences. Nevertheless, ADA complementary paratransit and general demand-responsive service provide public transit services, and there are significant areas of similarity with other transit modes as well.

As a result, applying performance measures to demand-responsive services must be done differently than for fixed-route services. Improvements to particular performance measures that would be seen as positive in a fixed-route environment may have negative consequences in a demand-responsive environment.

Significant differences exist between ADA complementary paratransit service and general demand-responsive services. Also, rural and contracted services (whether demand-responsive or fixed-route) have special considerations. Each will be examined separately. The role of each category of transit performance measures will also be examined with respect to ADA complementary paratransit and general demand-responsive service.

ADA Complementary Paratransit

ADA complementary paratransit service exists in urban areas. Since 1990, it has been required in conjunction with fixed-route and fixed-guideway systems. ADA paratransit service is provided to individuals who are unable to access fixed-route or fixed-guideway service as result of a disability.

Regulatory Constraints

Transit systems are required to adhere to a variety of regulatory guidelines contained primarily in 49 CFR Part 37, Subpart F, dated September 6, 1991. Many of the requirements set what are effectively general or specific performance standards that transit systems providing ADA complementary paratransit must adhere to. Table 10 details some of the impact that ADA regulation can have on performance measures.

Table 10. ADA Guidelines Impact on Performance Measures

Issue	ADA Guideline	Impact On Performance Measures
Eligible Persons *Subpart F 37.123*	Persons with disabilities shall meet one of three standards for service eligibility	Determines groups that shall be provided paratransit service
Eligibility Process for all applicants *Subpart F 37.125a*	Process shall strictly limit eligibility to individuals cited in Subpart F 37.123	Depends on the approach of the agency in assessing eligibility. Key measures are percentage of applicants approved and conditional versus unconditional eligibility
21-Day Rule *Subpart F 37.125c*	When an application is completed, an applicant must be informed of the decision within 21 days	Requires a measurement of average and maximum time for processing completed applications
No-Shows/Missed Trips *Subpart F 37.125h*	May suspend for a reasonable period of time persons who establish a pattern or practice of missed trips	Measures no-shows and missed trips as both gross number and percentage of total trips provided; measures suspensions for violations
Service Options *Subpart F 37.129*	a) Can provide origin-to-destination service b) Can provide feeder service to fixed-routes c) Can provide bus on-call (route deviation) service	Determines allowable service options
Service Area *Subpart F 37.131a*	Paratransit service provided ¾-mile on each side of a fixed-route except in areas outside of agency jurisdictional boundary	Minimum service area is determined
Next Day Reservations *Subpart F 37.131b*	Service shall be scheduled and provided for all requests for next day service	Requires service to be offered for trips the next day
Reservation Service Hours *Subpart F 37.131b*	Reservation service shall be available during normal business hours	Requires minimum hours that call takers must be available to process reservations
Pickup Time Negotiation *Subpart F 37.131b*	Trip cannot be required to be scheduled more than one hour before or after requested departure time	Limits the variance between trip time requested and time negotiated
ADA Fare *Subpart F 37.131c*	Agency may charge twice the full fare without regard to discounts for paratransit service	Limits farebox recovery ratio and the ability to increase fare to manage demand
Companion Fare *Subpart F 37.131c*	An individual accompanying the passenger pays the regular fare	Mandates additional demand for seat capacity
PCA Fare *Subpart F 37.131c*	A rider's Personal Care Attendant (PCA) shall ride free	Limits farebox recovery ratio and encourages PCA use
Trip Purpose *Subpart F 37.131d*	The agency cannot impose any restrictions or priorities on trip purpose	Cannot limit trip demand for any kind of trip
Hours and Days of Service *Subpart F 37.131e*	The hours and days of service must be the same as fixed-route service	Span of service must equal that of fixed-route service
Trip Denials *Subpart F 37.131f*	Current FTA and court interpretation is that any substantive amount of trip denials constitutes a capacity constraint and is a violation of the ADA	Measures service denials as performance; cannot use denials as a means to manage, discourage, or limit demand
Waiting Lists *Subpart F 37.131f*	Waiting lists for service access are not allowed	Cannot limit demand

Excessive Late Trips *Subpart F 37.131f*	The agency shall not have a significant amount of untimely pickups or return trips	Must monitor on-time performance
Missed Trips *Subpart F 37.131f*	Trips that arrive for the pickup more than one hour late	Must monitor missed trips
Excessive Trip Lengths *Subpart F 37.131f*	The agency cannot provide substantial trips with excessive length	Must monitor average and highest trip lengths.
Subscription Trips *Subpart F 37.133*	Subscription service is allowed. Cannot exceed 50% at a given time of day unless there is excessive capacity.	Monitor level of subscription service unless excessive capacity

ADA regulations have two primary impacts upon performance measures. First, ADA regulations require that certain standards, policies, and level of service be provided. Logically, an agency will have standards and measures to ensure that they are complying with regulations. Second, the requirements of ADA are not necessarily characteristic of general demand-responsive systems. Capacity constraints, waiting lists, and trip prioritization are all techniques used by other demand-responsive services to allocate limited resources. Capacity techniques for demand-responsive systems were developed because service volume is often limited and increasing service volume beyond existing financial and other resource capacity may be imprudent. Prohibiting such techniques in ADA paratransit leads to escalating demand and requires use of alternate demand management techniques, which can have less success.

Alternate techniques in managing ADA complementary paratransit demand have been a significant development in the decade since the passage of the ADA. Demand management techniques developed have become additional potential measurements for transit agencies. Potential demand management measures include

- Increasing thorough eligibility processes that include applicant pre-screening, interviews, functional assessments, mobility assessments, and cognitive assessments. Underlying this effort is an intent to limit eligibility to only those individuals who strictly meet the ADA requirement. Performance measures that can assess these efforts include *percentage of applicants approved* and *percent of conditional approvals.* Trend analysis and cost-benefit analysis of the cost of the screening assessments versus the cost savings in reduced potential ridership are other tools that can be used.
- Travel training of paratransit riders to use fixed-route service. Providing riders the skills and experience to use less costly fixed-route service is designed to reduce demand for paratransit and provide a community service by enhancing individual empowerment. Performance measures for this technique can include measuring the number of individuals successfully trained and the hours and resources needed to train them. Additional performance measures could examine whether the savings in ADA paratransit trips equal or exceed the hours and resources expended to train individuals.

PRODUCTIVITY LIMITATIONS

Productivity can be measured by *passengers per revenue hour* and *passengers per vehicle hour.* Fixed-route and fixed-guideway capacity productivity is limited only by the number of seats, standing spaces, and passenger trip lengths. Productivity levels are expected to be higher in fixed-route service than in ADA complementary paratransit and general demand-responsive service.

Demand-responsive productivity is limited by a variety of factors:

- Routes are variable and unpredictable from day to day.
- Pick-ups and stops are usually limited to one person.
- Distances and times between pick-ups are higher than for fixed-route service.
- Service is to residences and requires travel into subdivisions and slow travel streets.
- Persons with disabilities require additional time to board.
- Late trip cancellations and changes in itineraries are common and tend to disrupt scheduling.

Limited productivity means that providing service is much more expensive per person for demand-responsive service than for fixed-route service. ADA complementary paratransit service usually costs between eight and twelve times as much per passenger per trip as fixed-route and fixed-guideway service in large urban transit systems. ADA paratransit ridership may comprise 1 percent of total ridership but it may require 10 percent or more of the agency's operating expenses.

SERVICE DELIVERY APPROACH

Demand-responsive service requires different agency functions than fixed-route service. These different functions require performance evaluations that may not be applicable to fixed-route services. Examples of these differences include

- Advance trip reservations or same-day trip reservations require call takers to negotiate trips.
- Scheduling is fluid and ever-changing in demand-responsive service. Resources such as schedulers and/or an automated scheduling system are needed.
- Dispatching demand-responsive services is significantly more labor-intensive than for fixed-route services. Contact with passengers, lost drivers, and confirmation of pick-ups requires a lower ratio of dispatchers to drivers than for fixed-route service.
- Schedule changes are more frequent and unpredictable than in fixed-route service. Dispatchers and drivers are required to adapt more frequently to changing circumstances.

- Individuals apply to determine whether they are qualified to use the ADA complementary paratransit service, and their applications are assessed in some manner.
- Trips are made largely to or from passenger's residences resulting in a more one-to-one approach to service delivery.

Demand-responsive service delivery is more costly, and the varied functions provide the potential and need to assess an agency's performance of those varied functions.

GROWTH IN DEMAND FOR PARATRANSIT

Fixed-route transit growth often means that a higher percentage of seats is used during the hours of service. As a result, growth in fixed-route demand often results in a more cost-effective and efficient service. However, growth in the demand of demand-responsive paratransit can have a different impact. Demand-responsive service growth means additional pick-ups and drop-offs. As a result, more hours are needed to provide the additional service to meet the higher level of demand. The growth in demand is combined with the reality that costs per trip increase as a result of increases in the Consumer Price Index (CPI). Both increases will compound the rate of cost growth in paratransit. Given that transit operates in an environment of finite financial resources, growth in paratransit demand often means that ADA complementary paratransit service consumes an increasing share of total operating revenues, resulting in fewer operating resources available to fixed-route and fixed-guideway services.

The severity of this financial pressure has required transit agencies across the country to focus on efforts to address demand. As a result, measures that can assess the growth in demand have acquired a greater importance.

The potential for growing demand has created an interesting paradox as it relates to the provision of paratransit service. An underlying assumption of providing service in a public domain is that if the quality improves more individuals will purchase the service and the ridership increase resulting from higher-quality service is a desirable outcome. An increasing demand for ADA paratransit resulting from improved quality is certainly a desirable result in some respects; but in many instances, a strong downside also exists.

Increases in service requests indicate that more people are using the service and that the impact upon the community is more significant. Agencies generally want to do a better job and provide a better service so more people will use transit service.

However, if transit agencies with limited financial resources pursue an aggressive approach to providing quality ADA paratransit service, the increase in demand may result in severe financial pressures. This will significantly undermine efforts in areas where most individuals use transit service, specifically fixed-route and fixed-guideway. Therefore, agencies need to consider whether top-quality ADA paratransit service is desirable in a system-wide context, and if not, what level of quality is desirable?

The ADA regulations, productivity limitations, service delivery limitations, and the problems associated with the growth in demand are important components in developing realistic and useful performance indicators for ADA complementary paratransit service. Simply attempting to replicate fixed-route performance measures is not only inappropriate but also potentially significantly harmful to the agency's financial and operational health. Performance measures and standards should be tailored to the unique operational and regulatory environment in which ADA complementary paratransit operates.

GENERAL DEMAND-RESPONSIVE TRANSIT

The overall manner in which general demand-responsive service is provided is quite similar to ADA complementary paratransit. Both provide shared-ride service that is normally door-to-door or curb-to-curb service for the passenger. However, general demand-responsive service operates in a different environment and with a significantly different mission than does ADA complementary paratransit.

REGULATORY ENVIRONMENT

Extensive ADA complementary paratransit regulations do not directly apply to demand-responsive service. ADA is relevant, however, as equal access to persons with disabilities must be provided. Accessible vehicles are necessary as a significant component of a general demand-responsive fleet. The ADA specifies that there should be no pattern or practice of discrimination nor any difference between a person with disabilities' ability to receive a trip and that of an individual without apparent disabilities.

Other guidelines of the ADA are not required for general-demand paratransit since, in this system, everyone receives the same kind of public transit service. Unlike ADA complementary paratransit service, the following are permissible for general demand-responsive paratransit:

- Trip prioritization is permitted.
- Trips can be denied and the number of trips per month or week can be rationed.
- Hours for call taking for reservations are up to the transit agency.
- Fares can be set at any level.
- Waiting lists are allowed.
- The hours and area of service are determined by the transit agency, not by the level of fixed-route service.

The reduced number of applicable ADA guidelines allows a general demand-responsive service to ration demand in more ways and more easily than can ADA complementary paratransit service. Given this level of flexibility, the measurement of service has a number of similarities with fixed-route service, since the level and kind of service provision are much more flexible than in ADA complementary paratransit. Additionally, the service goal is to provide transit service to a wider range of passengers.

AGENCY MISSION

General demand-responsive paratransit service is designed for the entire public. Often, demand is largely concentrated in a few groups such as persons with disabilities, seniors, persons who are economically disadvantaged, or persons receiving service from various social and human service agencies. However, general demand-responsive paratransit service is often the only or primary means of public transit mobility within the area it serves.

Fixed-route and fixed-guideway service is the primary means of transit service for most medium and larger urban areas. Hence, the mission of general demand-responsive service is similar to the larger systems in that it is the primary means of public transit mobility. Service options with general demand-responsive service consist of where and how much service to provide, and thus involve fewer trade-offs than fixed-route service.

SERVICE DELIVERY APPROACH

General demand-responsive service requires different functions than fixed-route service. These different functions require performance evaluations that may not be applicable to fixed-route services. Examples of these differences include the following:

- Mechanisms must be in place for advance trip reservations or same-day trip reservations.
- Schedules can change quickly.
- Dispatching demand-responsive services is significantly more labor-intensive than for fixed-route services. Contact with passengers, lost drivers, and confirmation of pick-ups requires a lower ratio of dispatchers to drivers than fixed-route service.
- Demand-responsive service via door-to-door or curb-to-curb service is inherently less productive than fixed-route service.

Demand-responsive service delivery is more costly. The varied functions of this service provide the potential and need to assess an agency's performance of those functions.

GROWTH IN DEMAND FOR PARATRANSIT

The same agency cost impacts related to growth in demand for ADA complementary service also apply to general demand-responsive service. Growth in demand results in more service hours being required. At the same time, the cost per trip increases as a result of increases in the Consumer Price Index (e.g., wages, benefits, and fuel). Both increases result in compound cost growth in demand-responsive service, so that over time demand-responsive service consumes an increasing share of total operating revenues, and fewer operating resources are available for fixed-route and fixed-guideway services.

Since general demand-responsive paratransit normally provides the primary transportation service to the community it serves, demand is limited by the number of hours that financial, vehicle, and human resources will allow. Increases in demand beyond that level often require two approaches. First, an agency can ration service through denials, trip limitations or other means. Second, an agency can consider using potentially more productive modes such as fixed- or flexible-route service that provide more trips and possibly meet a higher volume of demand.

RURAL TRANSIT

Rural transit operates in a substantially different environment than most urban and suburban transit systems. Key environmental differences include

- Operation in areas of low densities;
- Large service areas;
- Limited funding;
- Not exclusively or even primarily for general purposes, but for a specific agency or purpose (such as Medicaid transportation); and
- Intensive coordination with other human and social service agencies.

General demand-responsive service is common in rural areas, but other modes are also provided, including fixed-route, flexible routes, planned subscription service, and vanpools. Transit service will, as a rule, be substantially more expensive on a per-passenger basis for rural service than for urban service, largely due to the lower densities and longer trip lengths. Transit agencies may not even operate transit service but operate as a transportation brokerage. A rural transportation brokerage will provide transit service for a range of agencies and clients. The brokerage will schedule service to providers and coordinate with other providers for service delivery.

Coordination and cooperation are keys to maximizing the level of service and performance in rural areas. While large urban systems can also benefit substantially from coordination and partnership efforts, these efforts may not be as essential as in rural areas.

Performance measures have traditionally focused on urban fixed-route service levels. Many of the traditional, internally focused performance measures can be relevant for rural systems but offer a more incomplete picture of transit's impact on the community and customers. The customer-service and community-focused measures presented in this Guidebook are valuable for rural systems, but these measures do not cover all aspects of rural service delivery.

Developing performance measures in a rural system therefore needs to start with an examination of the organization's goal and mission. Some questions to ask relate to the effectiveness and efficiency of coordination efforts:

- What service is the agency attempting to provide?
- What efforts are made to coordinate with other agencies?

- How can the results of those efforts be measured?

Possible performance measures for rural agencies or rural brokerages could be to evaluate if and how well coordination and partnership efforts are enhancing transit service. Since a brokerage service is largely concerned with the effectiveness of coordination and partnership, measuring performance based on the effectiveness of efforts (e.g., quality, efficiency, and quantity of trips and hours) and the satisfaction of the providers will be important.

SERVICE CONTRACTING

The service provided by contracted transit operators should be measured as a matter of public interest in order to do the following:

- *To ensure maximum value for money.* Measurement of the service is required to ensure that funds are allocated in the most appropriate and effective way.
- *To promote the use of transit.* The use of transit is dependent on public perception of the service. Measurement of the use of and satisfaction with transit ensures that the service is enhancing and not detracting from the initiatives to promote transit.
- *To avoid decreasing quality of service.* Without a long-term interest in providing good service quality, this service quality may decrease in the long term due to efforts to improve efficiency and cost-effectiveness.
- *To ensure fairness in selecting transit contractors.* Measuring the quality of service provided by a contractor is required to ensure that the selection of transit contractors is unbiased and results in the hiring of the most capable contractor who can provide a certain quality of service.
- *To reward good customer service and related initiatives.* Recognition of good customer service and initiatives to increase the use of transit encourages transit contractors to provide a high quality of service in a cost-effective manner.
- *To ensure the contract agreements are adhered to.* Monitoring the service provided by the service contractor ensures that the contractual arrangements and conditions of service are adhered to and that the level of subsidization for the service is appropriate.
- *To ensure the overall achievement of transit objectives.* Overseeing the current state of transit is necessary to ensure that the transit system meets its overall objectives.
- *To guarantee the long-term development of transit services.* Monitoring the development of the services enables the identification of issues, problems, and opportunities.
- *To ensure the interests of the public are paramount.* An accurate picture of the current situation is required to predict future trends and make responsible decisions.

PERFORMANCE MEASURES: CONTRACTOR PERFORMANCE

Specific targets and penalties/rewards must be set out in the contract to identify who is responsible for what.

The basis behind performance measures is to align the objectives of the contractor with those of the transit agency. The contractor and transit agency objectives may often conflict, as the contractor is generally profit-focused. As a result, efficiency and cost-effectiveness are of particular interest. The main aim of the transit agency is to provide quality transit service; thus customer satisfaction, service availability, and service delivery are important. By linking performance with financial rewards, the quality of service is directly related to the contractor's financial gain. Therefore, the financial and non-financial penalties and bonuses based on transit performance ensure that the actions of the contractor are in line with the transit agency's goals.

The performance incentives for a transit contractor must be

- Consistent with the agency's transit goals,
- Within the contractor's control, and
- Collected using a specified and agreed-upon method.

The contract must specify

- Frequency of performance reporting,
- Values against which the contractor's performance is compared,
- The length of the contract, and
- Provisions for terminating or renewing of the contract.

MEASURES OF CONSISTENCY WITH AGENCY GOALS

Contractor performance evaluation requires the establishment of clearly defined goals and the specification of performance measures appropriate for those goals. Therefore, prior to creating the measurements and penalties or rewards for contractors, the agency should be clear on the aims of the incentive system. The performance measures need to address the overall objectives of transit, in addition to issues with the local service and the initiatives for promoting transit use. The problems with promoting transit in the area in question should be determined. For example, the service may be unreliable or the transit system may be considered dangerous or unsafe. The measurements can then target the specific areas of concern.

MEASURES UNDER A CONTRACTOR'S CONTROL

The performance measures linked to contractor rewards and penalties need to be within the contractor's control. Without control over the aspects of the transit operation that the performance measures are based on, there is no incentive for the contractor to produce quality service. For example, if altering existing transit routes requires a lengthy approval process, a penalty or bonus attached to mobility and access measures such as service coverage is not appropriate. This problem was identified with past incentive/penalty systems in which the incentives to the contractors for good quality service were based on fare revenue. However, the contractor did not have control over fare revenue, with the fare structure being imposed from outside.

MEASURES COLLECTED USING A SPECIFIED AND AGREED METHOD

It is important that how the performance indicators are measured is agreed upon by the contractor and the transit agency. A number of different collection methods, each giving a different result, can be used to calculate a particular incentive measure. For example,

- *Customer complaints measures.* Are written, Internet, or telephone complaints included, and are repeated complaints by the same person considered as one complaint in total or as a separate complaint each time?
- *Delay-based performance measures.* What constitutes "on time" service? How many minutes early and late can a service be before it is considered to be no longer on time? Is this measured from the first and last stop or at major stops along the route? Are all services considered or only weekdays?

The performance measures are effectively out of a contractor's control if there is not an agreed-upon method for data collection that is consistent throughout the transit contract. This problem has been experienced with some incentive/penalty systems, with penalties based on observations from a variety of sources with no guarantees of consistency or uniformity.

The way in which major events interrupt the transit service must also be specified. For example, if a storm causes a tree to fall and block a rail line, is the service disruption included or excluded from the reported transit performance? Regular sporting or cultural events that affect some contractors may also need to be examined to determine whether they are included within the performance results. Major events such as football games with large numbers of patrons attempting to access transit at the same time can artificially and perhaps unjustly lower the performance indicators for a particular operator. This can be unfair if only particular operators are affected and their performance is compared to that of unaffected operators.

VALUES AGAINST WHICH THE CONTRACTOR'S PERFORMANCE IS COMPARED

The measures against which the contractor's performance is compared have to be determined. A contractor's transit performance can be compared with

- The contractor's previous results,
- Other contractors' results from the agency's area or from similar areas,
- Static performance targets, and
- Dynamic performance targets.

When dynamic (changing) performance targets are used, the method by which the target changes must be specified. If the measure is linked to something outside the contractor's control (e.g., the inflation rate), the incentive for the contractor to produce quality transit can be negated.

FREQUENCY OF PERFORMANCE REPORTING

The frequency of performance reporting must be specified in the transit contract. When reporting periods are too short, long-term service improvements may be ignored in favor of short-term fixes to ensure quick returns. When reporting periods are too long, potential problems may not be identified and acted upon before they affect customer satisfaction and ridership. Performance reporting periods utilized in performance contracts include monthly, quarterly, semi-annual, and annual.

THE LENGTH OF THE CONTRACT

The length of the contract and the provisions by which the contract is terminated or renewed must also be specified. The issue of the length of contracts for transit contractors has serious implications for the quality of service provided. A contract term that is too short may not provide enough time for contractors to identify quality of service issues and implement changes to improve performance.

THE TERMINATION OR RENEWAL OF THE CONTRACT

The renewal or reopening of competition for a contract is a contentious issue, as there is a distinct comparative advantage to the current contractor. An issue to consider is whether the contract should be open for proposals again after the specified term, or whether it should remain with the current contractor unless the contractor has demonstrated poor service quality.

SUMMARY OF CONTRACTOR PERFORMANCE MEASURES

The contract must specify the measure for each individual transit goal and the target level of achievement. A single goal, such as customer satisfaction, could be determined using a number of different measures (e.g., an incentive measure that a certain percentage of customer satisfaction must be achieved each period). Customer satisfaction may be measured by the percentage of customers making complaints, or the percentage of customers reporting a specified satisfaction level on a survey.

For each incentive or penalty, it is necessary to define the

- Objectives,
- Measure to be used for each objective,
- Required level to be achieved,
- Minimum level to be achieved, and
- Incentive for the achieved level.

PERFORMANCE MEASURES: AGENCY PERFORMANCE

The use of performance measures does not remove the responsibility of the transit service from the agency to the contractor. The contract assigns the responsibilities and rewards between the agency and the contractor. The agency must scrutinize on an on-going basis the following:

- *The efficiency of the contractor.* The agency needs to monitor the operator to ensure contract adherence to allocate the appropriate bonuses or penalties.
- *The effectiveness of the performance measures.* The performance measures need to produce the required quality of service and need to be consistent with the agency's goals.

In addition, an agency may measure transit performance for a variety of reasons, including effectiveness, efficiency, quality of service, and social reasons. Therefore, not all of the measures used by a transit agency may be related to a particular contractor. These additional measures do not necessarily have to be within the contractor's control, as they are not used to evaluate the contractor's performance. The additional measures may be related to aspects of transit under the transit agency's control, such as fare structure or route coverage.

CORE PERFORMANCE MEASURES

Users of this Guidebook are encouraged to use the performance measure selection menus in Chapter 6 to match appropriate performance measures to their goals and objectives. However, it is also appropriate to check whether a sufficiently broad range of measures is also being incorporated into the agency program. This section provides a set of recommended core performance measures that can form the basis for a community- and customer-focused performance-measurement program.

FIXED-ROUTE

The larger the transit agency, the greater the number of issues to deal with, but the greater the number of resources available to it. Tables 11 through 17 present recommended measures for different sized transit agencies:

- Large (over 1 million population),
- Medium (200,000 to 1 million population),
- Small (50,000 to 200,000 population), and
- Under 50,000 population (providing fixed-route service).

The number and complexity of recommended measures increases as the system size increases. The measures provided for larger systems represent measures that all systems, at a minimum, would ideally measure to cover all perspectives of their performance. The smaller systems have fewer measures listed, because it is recognized that they often do not have the resources to measure as much as might be desired.

Consistent with this Guidebook's recommendation that agencies begin with a small program and expand it over time, most agencies would not want to try to implement all of the listed measures at the start. Instead, as agencies gain experience with performance measurement, the full complement of core measures, plus other measures specific to agency goals or objectives, can be provided.

The following tables address the following aspects of transit service:

- Service availability: Table 11;
- Service delivery: Table 12;
- Safety and security: Table 13;
- Community impact: Table 14;
- Maintenance: Table 15;
- Financial performance: Table 16; and
- Agency administration: Table 17.

The tables are organized similarly. Shaded areas indicate performance measures not included in the recommended core program for a given agency size. The combination of all of the measures listed in the tables for a given agency size constitute the recommended core program; however, as stated above, most agencies will want to begin with a subset of the core program.

Table 11. Core Fixed-Route Service Availability Measures

<table>
<tr><th>Large</th><th>Medium</th><th>Small</th><th>Under 50,000</th></tr>
<tr><td colspan="2">Service coverage</td><td colspan="2">Route coverage</td></tr>
<tr><td colspan="4">Frequency</td></tr>
<tr><td colspan="4">Hours of Service</td></tr>
<tr><td colspan="3">Stop Accessibility</td><td></td></tr>
</table>

Table 12. Core Fixed-Route Service Delivery Measures

<table>
<tr><th>Large</th><th>Medium</th><th>Small</th><th>Under 50,000</th></tr>
<tr><td colspan="4">Missed trips</td></tr>
<tr><td colspan="4">Complaint rate</td></tr>
<tr><td colspan="4">Route directness</td></tr>
<tr><td colspan="3">On-time performance</td><td></td></tr>
<tr><td colspan="3">Customer response time</td><td></td></tr>
<tr><td colspan="3">Passenger load</td><td></td></tr>
<tr><td colspan="3">Reliability factor</td><td></td></tr>
<tr><td colspan="3">Transit-auto travel time</td><td></td></tr>
<tr><td colspan="2">Number of fare media sales outlets</td><td></td><td></td></tr>
<tr><td colspan="2">Customer satisfaction</td><td></td><td></td></tr>
<tr><td>Headway regularity</td><td></td><td></td><td></td></tr>
<tr><td>Pass. environment</td><td></td><td></td><td></td></tr>
<tr><td>Customer loyalty</td><td></td><td></td><td></td></tr>
</table>

Table 13. Core Fixed-Route Safety and Security Measures

Measure	Large	Medium	Small	Under 50,000
Accident rate	X	X	X	X
Number of incidents of vandalism	X	X	X	X
Crime rate	X	X	X	
Number of vehicles with specified safety devices	X	X	X	
Passenger safety	X	X		
Ratio of police officers to transit vehicles	X	X		

Table 14. Core Fixed-Route Community Impact Measures

Measure	Large	Medium	Small	Under 50,000
Personal economic impact	X	X	X	X
Demographics	X	X	X	
Communications	X	X	X	
Mobility	X	X		
Service equity	X	X		
Community economic impact	X	X		
Environmental impact	X	X		
Visual impact	X			

Table 15. Core Fixed-Route Maintenance Measures

Measure	Large	Medium	Small	Under 50,000
Road calls	X	X	X	X
Average spare ratio vs. scheduled spare ratio	X	X	X	X
Fleet cleaning	X	X	X	X
Maintenance work orders: model vs. fleet	X	X		
Average life of vehicle components	X	X		
Average age of vehicle components	X	X		
Mean vehicle age	X	X		
Maintenance program effectiveness	X	X		
Fleet maintenance performance	X	X		

Table 16. Core Fixed-Route Financial Performance Measures

Measure	Large	Medium	Small	Under 50,000
Ridership	X	X	X	X
Productivity	X	X	X	X
Cost-effectiveness	X	X	X	X
Cost efficiency	X	X	X	
Energy consumption	X	X	X	
Risk management	X			

Table 17. Core Fixed-Route Agency Administration Measures

<table>
<tr><th>Large</th><th>Medium</th><th>Small</th><th>Under 50,000</th></tr>
<tr><td colspan="4">Percent positive drug/alcohol tests</td></tr>
<tr><td colspan="3">Employee productivity</td><td></td></tr>
<tr><td colspan="3">Employee relations</td><td></td></tr>
<tr><td colspan="2">Employee work days lost due to injury</td><td></td><td></td></tr>
<tr><td colspan="2">Administrative performance</td><td></td><td></td></tr>
</table>

DEMAND-RESPONSIVE

ADA complementary paratransit and general demand-responsive service operate in a significantly different environment than fixed-route and fixed-guideway service. While significant differences exist, both modes are public transit services designed to meet various goals; seven of the Guidebook's eight general categories of performance measures are applicable to both services.

CATEGORIES OF DEMAND-RESPONSIVE MEASURES

The seven general categories of performance measures applicable to both ADA complementary paratransit service and general demand-responsive service are availability, service monitoring, community, travel time, safety and security, maintenance and construction, and economic measures.

AVAILABILITY MEASURES

Service availability in ADA complementary paratransit is based upon the ADA requirements of minimum service in terms of span and time of service. However, service can be provided more broadly. Demand-responsive service availability will be based on the agency's resources and its allocation of them in the area it serves. Measures vital for ADA complementary paratransit include

- *Service coverage*: required to determine ADA compliance,
- *Span of service*: required to determine ADA compliance,
- *Service hours*: the effort required to provide service,
- *Revenue hours*: used to calculate productivity, and
- *Service denials*: necessary to determine whether a capacity constraint exists (and how severe the constraint is, if one exists).

All of these measures would also be significant for general demand-responsive paratransit service.

SERVICE MONITORING MEASURES

Measures of passengers' day-to-day experiences with respect to reliability and customer service are significant. Passenger loading is generally less of an issue in demand-responsive service.

Knowing where an agency stands is significant in these performance-monitoring measures:

- *On-time performance* is critical in both ADA complementary paratransit and general demand-responsive service as a reliability issue. Significantly poor levels of on-time performance are indicative of a lower level of service reliability. However, the ADA for complementary paratransit indicates that a sufficiently high level (never specifically defined) of late trips can qualify as an impermissible capacity constraint. Service efficiency can be improved by increasing system speed, but this may result in poorer on-time performance. Reliability and efficiency can be conflicting goals, and an agency will need to determine the appropriate balance between them.
- *Missed trips*, those trips that are more than 1 hour late, can be used in both ADA complementary paratransit and general demand-responsive service as a reliability issue. However, excessive missed trips (again not defined in ADA) can be viewed as an impermissible capacity constraint.
- *Complaint rate* can be a measure of customer satisfaction, although it has a subjective component. Rates can be measured per passenger, per mile, or per service hour.
- *Percentage of missed phone calls* is a performance measure for either information or reservations centers. All demand-responsive systems will have some means of reserving trips and this is most appropriate in systems serving over 100 trips a day, where customer phone access is an issue. Missed phone calls should be generally monitored as an accessibility issue related to obtaining ADA service. The *percentage of calls on hold excessively long* would be another measure to consider.
- *Response time* to inquiries is an important means of determining responsiveness and should be considered as a reliability responsiveness measure.

COMMUNITY MEASURES

Community measures would be used to indicate and measure the potential value of the demand-responsive service and ADA complementary paratransit modes in their respective communities. The complexity of many of these measures would result in significant challenges to general demand-responsive agencies with limited resources to measure these kinds of macro-impacts.

- *Welfare-to-work accessibility* could be a significant general demand-responsive measure, since it would show that transit was providing the means for welfare recipients to access work.

- *Personal* and *community economic impacts* would be valuable, as they provide an understanding of the positive role of transit in community development.
- Provision of transportation service to human and social service agencies (e.g., *number of trips made, number of persons served,* or *number of agencies contracted with*).

ADA paratransit's role in community measures should be viewed as a component of the agency's overall benefits and impact of transit service, rather than viewed separately.

TRAVEL TIME MEASURES

Travel time measures are a significant indicator of the quality and effectiveness of transit service. *Travel time* is important for ADA complementary paratransit since trip travel time on paratransit should be comparable to travel on fixed-route service. Excessively long travel times can be viewed as a capacity constraint. However, significantly shorter travel times on paratransit for a given trip, compared to fixed-route service, encourage the use of more costly ADA complementary paratransit for those trips, which results in negative financial impacts for transit agencies.

System speed is important to measure in two respects. First, the average scheduled system speed should be known. A second measure is the average system speed that is actually provided. Actual speed will have a large impact on the potential productivity of an ADA complementary paratransit service.

SAFETY AND SECURITY

Safety and security issues are relevant to passenger confidence and to control of liability and insurance costs of both services. An applicable measure in this area is the *accident rate*.

MAINTENANCE AND CONSTRUCTION MEASURES

How well an agency maintains its vehicles is an important concern in demand-responsive service. Demand-responsive service generally uses smaller transit vehicles that have a much shorter service life than larger, medium- and heavy-duty buses and fixed-guideway vehicles. The key measure among this group for demand-responsive service is *road calls*, which measures vehicle reliability and the effectiveness of the preventive maintenance program.

ECONOMIC MEASURES

Given the significant financial constraints that both ADA complementary paratransit and general demand-responsive service operate under, this area has several significant measures to consider:

- *Ridership* is the critical component of demand, since both ADA complementary paratransit and general demand-responsive service have limited economies of scale. Increases in ridership will generally require additional resources.

- *Cost efficiency* will indicate the direct costs to provide service. Cost per vehicle hour is a common measure of efficiency. Cost per hour also can be a critical measure to determine the marginal cost to provide service for an hour more or an hour less.
- *Cost-effectiveness*, measured as the *cost per passenger*, is a critical measure based on the system productivity and the cost to operate each hour of service. Cost per passenger is normally significantly higher in ADA complementary paratransit and general demand-responsive service. Therefore, passenger increases result in cost increases. In contrast, passenger increases in fixed-route services often result in lower costs per passenger due to the many economies of scale that exist in fixed-route service.
- *Productivity* is a key component of the cost of providing service. Demand, service area size, scheduling resources, scheduling parameters, cancellations and no shows, and traffic congestion can all impact productivity. However, demand-responsive service has significantly less potential capacity than fixed-route service and, in reality, productivity is much lower in both ADA complementary paratransit and general demand-responsive service.
- Recent experience shows that monitoring trip *no-shows and late cancellations* can be useful in controlling service cost and enhancing service effectiveness. General demand-responsive service can also be negatively impacted by missed trips that waste planned service resources.
- Identification of alternate funding sources allows a wider provision of service and possible economies of scale through the more effective coordination of service delivery.

ALTERNATE APPROACH TO PERFORMANCE MEASURES AND ADA COMPLEMENTARY PARATRANSIT

Providing quality ADA complementary paratransit service at a cost that will not negatively impact other types of transit service delivery is a very substantial challenge for transit agencies across the country. Many transit agencies in the United States have grappled with the apparent paradox of providing quality ADA complementary paratransit service to persons with disabilities in a fiscally sound manner.

Providing ADA complementary paratransit as a self-contained service delivery system is a great challenge to transit agencies. Measuring the performance of ADA complementary paratransit as the transportation service for persons with disabilities would not be consistent with the transportation approach envisioned in the ADA. The ADA vision is that the primary modes of transportation for urban systems (fixed-route and fixed-guideway service) should also be the primary mode of public transportation for persons with disabilities.

Therefore, performance measures designed to ascertain the level of accessibility and mobility for persons with disabilities should not solely focus on ADA complementary paratransit. Performance measures should also analyze the level of mobility and accessibility provided to persons with disabilities by all modes. One telling statement in the ADA regulations as they relate to this concept is that a person with a disability is entitled to an equivalent level of transit service be it "good, bad, or indifferent." Often the quality of service provided to persons with disabilities (when taken in consideration of all modes) will largely mirror service quality and accessibility for persons without an apparent disability.

Over the last decade, transit agencies and consultants have developed a variety of approaches to providing transportation services to persons with disabilities while addressing the transit requirements of the ADA. A multi-pronged approach to addressing the issue is often recommended, with the prevailing wisdom that no single approach will successfully resolve all of the issues with providing ADA complementary paratransit.

Among the approaches recommended or developed:

- Ensuring through professional eligibility assessments and interviews that only qualified individuals obtain service;
- Using the assessment process to educate persons with disabilities about the availability of alternatives to demand-responsive service;
- Providing persons with disabilities the requisite skills to use fixed-route service, through travel training;
- Ensuring that not only is the fixed-route bus fleet entirely accessible, but also that paths to and from bus stops are accessible. Many persons with disabilities are prevented from using fixed-route service due to inaccessible (or non-existent) sidewalks and curb cuts;
- Providing a two-tier approach to demand-responsive delivery with a minimal level of ADA complementary paratransit service and a second level of demand-responsive service that is beyond the ADA and offers a higher level of service (often at an increased cost);
- Providing transportation alternatives that offer same-day trips, such as taxicabs, in order to enhance mobility;
- Providing flexible-route, neighborhood circulator, and point-deviation services that allow a greater level-of-service efficiency, while providing an alternative to demand-responsive service; and
- Developing financial incentives to ride fixed-route service by providing free rides on fixed-route to individuals who are certified as ADA-eligible.

Transit systems across the country are using some or many of these approaches, but often their performance measures focus only on fixed-route and paratransit efficiency.

Broadening the definition of providing quality and cost-effective transportation service to persons with disabilities beyond specific modes can be a valuable strategic approach. Measuring effectiveness can allow a more complete perspective to staff, governing authorities, persons with disabilities, and the public at large regarding the level of transit service for persons with disabilities. The alternate approach outlined here is also consistent with a more customer-oriented and community-based approach to performance measures. Focusing not on the specific transit service delivery mode, but on the level and quality of mobility offered, successfully provides that perspective.

Approaching issues related to service accessibility based upon available mobility options can allow a different assessment of transportation. Measurements would include ADA complementary paratransit only as a component of the analysis. For example, the ridership level of persons with disabilities may be considered a measure of service accessibility. However, this ridership would not mean only ADA complementary paratransit, but the total transit ridership of persons with disabilities on all transit services.

Additional measurements could include the

- Number of applications professionally assessed and the percentage approved;
- Percentage of accessible vehicles;
- Percentage of available and accessible sidewalks and curb cuts adjacent to bus stops;
- Number of individuals travel-trained and the percentage using fixed-route service as a primary transportation mode, in place of paratransit;
- Total ridership of persons with disabilities and the distribution of ridership among fixed-route and paratransit services;
- Total average cost per trip for persons with disabilities using all transit modes;
- Passenger-per-hour productivity of transportation for persons with disabilities, including all transit modes; and
- Persons with disabilities transported to work or jobs in all modes of service.

Incorporating some of these measures can result in a more comprehensive evaluation of the level of service and performance provided to persons with disabilities.

EXAMPLE APPLICATION

INTRODUCTION

This section is intended to provide a transit agency with additional guidance in the actual process of setting up a performance-measurement program. For a more thorough step-by-step description of this process, refer to the beginning of this chapter for additional details and case study examples. This section will also serve the purpose of summarizing the eight steps.

HYPOTHETICAL EXAMPLE

To help illustrate the process of setting up a performance-measurement system, imagine the following scenario:

Morgan Valley Transit Authority (MVTA), a mid-size transit agency, had been experiencing declining systemwide ridership over a period of 3-5 years and was struggling to identify corrective actions to boost ridership figures. MVTA's service area is fairly typical of most mid-size transit agencies in the United States, with dispersed trip generators scattered throughout a predominantly suburban community. While a central business district still exists in the community's urban core area, it has ceased to serve as the center of commerce and employment for Morgan Valley residents. These more decentralized development patterns have created numerous challenges for MVTA and have contributed significantly to the creation of a highly automobile-oriented community.

As would be expected, the General Manager (GM) of MVTA was quite concerned with the declining ridership trends and decided to initiate measures to increase systemwide ridership figures. Prior to implementing these corrective measures, the GM recognized that there must be a better understanding of all of the factors leading to the declining ridership in the first place. Unfortunately, MVTA had never developed a performance-measurement program, which severely handicapped the GM's ability to understand the critical issues facing MVTA and potential strategies for addressing these issues. Realizing this constraint, the GM called a meeting with the board of directors to collect feedback and discuss opportunities for improving MVTA's ability to evaluate its performance.

Step 1: Define Goals and Objectives

During the board meeting, MVTA's senior management decided that the creation of a performance-measurement program was long overdue. MVTA's board and senior management also agreed that goals and objectives must be defined as the first step in setting up a performance-measurement program. Over the course of the next few months, goals were developed for MVTA that included the following:

- Improve system performance,
- Increase ridership figures, and
- Develop the ability to monitor performance.

Although many other goals were considered, MVTA's senior management decided that it was best to begin with a small set of simple goals that could be expanded as time went by. Corresponding objectives were also defined for each of the goals presented above. MVTA also agreed that these goals and objectives should be evaluated and updated on a fairly regular basis to ensure that they were still representative of the system's priorities.

Step 2: Generate Management Support

In establishing its performance measurement program, MVTA was fortunate to have taken a top-down approach, since this assures the transit system of enjoying management support for the program. Transit systems without this luxury must take steps to develop management support, such as educating board members and senior management regarding the value of performance monitoring. In MVTA's case, the system's board requested that agency staff create aggregate performance measures and conduct monthly reporting, such that board members could stay involved and remain knowledgeable concerning the system's performance.

Step 3: Identify Internal Users, Stakeholders and Constraints

As the system progressed in establishing its performance measurement program, MVTA recognized the importance of being realistic in its expectations for the program. For MVTA, this realism was manifested in the system's ability to recognize constraints in its data collection abilities, as well as a consideration for the overall purpose of the program, which included factoring in the participating users and stakeholders. Through this process, MVTA decided that it would not have the financial resources available to implement many new data collection technologies as part of the performance-measurement program. Instead, MVTA decided that the system would have to rely upon more traditional data collection techniques, such as drivers' daily operating logs and passenger counts. As new technologies are refined and developed, MVTA intends to re-evaluate the financial viability of these data collection approaches.

Step 4: Select Performance Measures and Develop Consensus

Having settled upon a low-cost, low-technology approach to data collection, MVTA was able to settle upon a fairly modest collection of performance measures to evaluate its service and cost efficiency and cost-effectiveness. These performance measures included the following:

- *On-time performance*,
- *Passengers per hour* and *passengers per mile*,
- *Farebox recovery ratio*,
- *Accident rate* (per 100,000 miles),
- *Road call rate* (per 100,000 miles), and
- *Cost per passenger* and *cost per revenue hour*.

Despite the measures' simplicity, MVTA staff thought that these measures would provide the system with the ability to effectively measure performance and move the system toward achieving its overall program goals. MVTA also took strides to develop consensus on the chosen performance measures by encouraging all involved parties to critique and scrutinize the measures throughout the development process.

Step 5: Test and Implement the Program

Once MVTA finally settled upon its set of performance measures, the transit system initiated a pilot program to test its ability to effectively collect and analyze the necessary data. There were several glitches in the pilot program, such as data gaps and processing challenges; but MVTA was able to address these glitches through careful and attentive program oversight.

Because MVTA had not measured its performance before, it was not sure what would be appropriate targets to set for each of its selected measures. One benefit of the pilot program was that it provided an initial set of performance results that MVTA could then use to get a sense of how well it was doing compared with its peers. Using the Florida Transit Information System (FTIS) software included on this Guidebook's accompanying CD-ROM, MVTA was able to identify an initial set of potential peer agencies based on service area population and number of vehicles operated. Management then narrowed down the list of peer agencies by eliminating those that managers knew from experience, or learned through contacts with the potential peers, had local conditions that were considerably different than the conditions MVTA operated under.

Peer results for all of MVTA's selected performance measures, save two (*on-time performance* and *road call rate*), could be derived from National Transit Database information, and MVTA again used the FTIS software to access this information for its peer agencies. Through a series of calls to its peer agencies, MVTA found that most of them already measured road call performance; and MVTA was able to determine an average road call rate for its peers. The same series of calls determined that far fewer peers measured on-time performance, and those that did, measured it in different ways. As a result, MVTA was not able to determine an average on-time performance rate from its peers. Instead, MVTA turned to this Guidebook, which led the agency in turn to *TCRP Synthesis of Transit Practice 10* (***48***) and the TCQSM (***2***), which provided information about on-time standards used by agencies and on-time performance as viewed by passengers, respectively.

MVTA decided as an initial set of targets to (1) work to improve performance to the peer group average, where MVTA's performance was below average, and (2) to improve performance by 10 percent over the next year in the areas where it was above average (e.g., if the accident rate was 2 accidents per 100,000 miles, the agency's target would be a rate of 1.8 accidents per 100,000 miles, a 10% reduction in the rate).

Step 6: Monitor and Report Performance

Program implementation went quite well for MVTA, although the system continued to evaluate program effectiveness and make changes as deemed appropriate. As per the board's original request in the program's inception, MVTA staff was committed to providing monthly reports regarding the system's performance. These reports had to be modified several times to continue to meet the changing needs of the board. Additionally, MVTA staff prepared separate performance measurement reports for internal use and system evaluation. Regardless of the report format, MVTA remained committed to reporting and analyzing system performance, since this step represented the "harvest" of all the hard work that had gone into developing and refining the program.

Step 7: Integrate Results into Agency Decision-Making

MVTA recognized that integrating program results into its decision-making process was perhaps the most important step in the entire performance-measurement process. Because the board and the GM viewed the program as an important tool for decision making, MVTA was readily able to use the results of the program to identify areas of necessary service changes and recommend appropriate improvements. Based on these efforts, MVTA was able to address its declining ridership by cutting unproductive routes and adding new, innovative service to attract new transit riders. Its performance-measurement system was vital in determining which routes were efficient and effective and which were not, thus saving the system money and allowing it to provide better service that attracted new riders.

Step 8: Review and Update the Program

MVTA's performance-measurement program is still in its infancy and the transit system has not yet had the opportunity to review and update the program. Nonetheless, the transit system recognizes the importance of continual evaluation of the program's goals and has scheduled a review of the performance-measurement program during its next planning cycle.

SUMMARY

The hypothetical example presented above is intended to provide the reader with an improved ability to conceptualize the process of setting up a performance measurement program. By demonstrating the way in which MVTA implemented the eight-step process presented earlier in this chapter, this section has highlighted several key points that are worth summarizing in closure.

The first important point is that performance-measurement programs do not have to be expensive to set up or operate. As long as the program is well thought-out and designed, simple data collection processes can be quite effective in providing a transit system with useful and valuable information by which to evaluate performance.

A second important point is that there is no substitute for strong management support when it comes to performance-measurement programs. Although the MVTA example is hypothetical, typical agency experience is that without a high level of support from an agency's board and senior management, a performance-measurement program will not be particularly effective.

Finally, MVTA remained focused on its program goals and objectives and was able to utilize the improved level of information from its performance-measurement program to identify corrective actions intended to move the agency toward achieving its goals.

— 5 —

PERFORMANCE MEASUREMENT TOOLS

Chapter 5 presents a variety of resources for agencies that are preparing or updating their performance-measurement programs. Major topics presented in this chapter include

- Categories of performance measures, including their uses, typical data needs, and typical reporting intervals;
- Types of performance measures, and guidance on their use, ranging from simple individual measures to complex indices;
- Potential sources of data for evaluating particular measures and guidance on their use;
- Guidance on developing performance standards; and
- Guidance on reporting results.

PERFORMANCE MEASURE CATEGORIES

As suggested by Figure 1 in Chapter 2, transit performance measures can be divided into a number of categories, based on their focus and likely audience(s). This section lists the categories of measures used in this Guidebook, the factors that those measures address, typical resources needed to calculate the measures, and typical reporting frequencies. (Measure-specific information is provided in Chapter 6.) An agency may wish to develop goals and associated measures for these categories.

AVAILABILITY

The availability of transit service is vital for potential passengers: if transit service is not provided to the locations where people want to go and at the times they need to travel, transit is of little use to them. *TCRP Web Document 12* (***6***) shows how changes in transit availability affect ridership.

Most aspects of availability are under the control of the transit agency, within the constraints of the agency's financial, staff, and capital resources. These aspects include where, how often, and how long service is provided; how easily potential passengers can learn about the service; and whether capacity constraints limit availability.

Some aspects of availability may not be under an agency's control, but are worth tracking anyway, to provide information useful to other public agencies that may lead to transit-supportive facilities being provided. These measures can also help prioritize where service is provided, based on where service is more likely to be productive. Measuring the ease of access to and from stops (*stop accessibility*) plays an important role in whether people can actually use the service provided at those stops.

Many measures of availability are straightforward to calculate, requiring only basic schedule and route data, such as public timetables and system maps. More detailed measures, particularly of service coverage, usually require geographic information system (GIS) software. Factors measured by availability tend to change infrequently, which means that, in most cases, the measures can also be calculated infrequently. Service coverage measures can be assessed annually, while temporal availability measures need be measured only as often as service changes, typically quarterly to annually. The major exception to these guidelines is ADA paratransit *service denials*, which should be calculated at least monthly, to quickly identify any capacity deficiencies that could lead to non-compliance with the ADA.

SERVICE DELIVERY

Service delivery measures assess passengers' day-to-day experiences using transit. Many of these measures assess things directly under the control of a transit agency, while others are at least partially influenced by external factors, such as passenger demand and traffic congestion. These measures can evaluate service reliability, the quality of interactions between customers and agency staff, passenger comfort, overall customer satisfaction and loyalty, and how well the agency has achieved shorter-term project goals.

Service delivery measures tend to require large amounts of data, collected on a regular basis. The simpler measures require only that good records and logs be kept. More complex measures require extensive manual or automated data collection, while the most complex require specialized customer satisfaction or passenger environment surveys. Most measures should be reported at least monthly, to maximize their usefulness in identifying potential problems.

In addition to the importance of regular data collection, service delivery measures are extremely valuable in first identifying the areas of greatest importance to customers and then quickly resolving any identified problems in those areas before they discourage customers from using transit.

COMMUNITY

Interviews with 19 agencies having performance-measurement programs conducted for this TCRP project revealed that most of those agencies did not measure their impact on the communities they served. The agency with the most extensive set of community-related measures was not a transit agency but a metropolitan planning organization (SANDAG, in San Diego).

The American public rates transit relatively low compared to other public services and issues such as education, crime, and pollution (***20***). Since a number of small- and medium-sized agencies have no fixed funding source, it is important that these agencies make the best possible case about the benefits of transit service to individuals and the community as a whole.

Community measures assess the impact of transit services on such quality-of-life issues as mobility, job access, vehicle trip reduction, personal finances, property values, and pollution. They also can be used to identify areas that may be productive in terms of ridership and to evaluate how equitably transit service is distributed in the region. These measures are typically evaluated annually or in association with a particular major transit project.

Most community measures require access to data a transit agency would not normally have on hand, but that a metropolitan planning organization or city planning department would have. Similarly, these measures frequently require the use of GIS software and/or data from a regional transportation planning model, which planning agencies can often access. Consequently, transit agencies are strongly advised to work in partnership with the local MPO when developing and evaluating community measures.

TRAVEL TIME

Travel time measures assess how long it takes to make a trip by transit, either by itself or in relation to another mode, such as the automobile. These measures can also be used to assess how quickly persons or transit vehicles can travel between two points, how many transfers are required, and how variable travel times are from day to day. Trips that take too long to make, particularly in relation to the automobile, will be unattractive to potential passengers.

Time-related measures are useful for evaluating the service quality of particular trips, while speed-related measures are useful for evaluating the service quality along particular facilities. Both types of measures are useful for demonstrating the effects of traffic congestion on scheduled run times for routes and, when additional buses are required to maintain headways, the resulting effects on an agency's bottom line. They are also useful for identifying the need for more direct or faster service between two locations. *TCRP Web Document 12* (***6***) briefly discusses the impacts of changes in travel time, particularly in wait and transfer time, on transit ridership.

A number of travel time measures require data that are most easily obtained through automatic vehicle location (AVL) equipment. These data can also be obtained from field data collection or from data generated by the regional transportation planning model. Most measures can be evaluated annually, in conjunction with planning for service changes.

SAFETY AND SECURITY

These measures evaluate the likelihood that passengers will be involved in an accident (vehicular or otherwise) (*safety*) or become the victim of a crime (*security*). They can also measure various aspects of workplace safety. In many instances, customer *perceptions* of safety and security are as important to understand as the actual conditions; a customer satisfaction survey can assist in uncovering these perceptions.

Most safety and security measures are straightforward to calculate and require little more than careful record-keeping. Measures reflecting actual incidents should be reported more frequently (e.g., monthly), while indirect measures reflecting potential levels of safety and security, such as the ratio of *transit police officers to transit vehicles*, can be reported annually.

Crime information is an area where accurate comparisons between agencies can be difficult due to differences in reporting methods. Agencies having their own police forces might report all crimes their officers responded to, even those not on transit property. Other agencies will have different procedures about reporting crimes. Similarly, it may be difficult to distinguish safety issues between agencies without comparing actual records (e.g., was a reported fatality a passenger aboard a vehicle or was it someone trespassing on the agency's tracks?).

Maintenance and Construction

Maintenance measures reflect the quality of the agency's maintenance program, the quality of purchased vehicles, and the impacts of that quality on the overall quality of service that passengers perceive. Construction measures assess the impact of transit construction on passengers affected by the construction.

Many of the maintenance measures are most useful to maintenance staff, to help them run the maintenance department as efficiently as possible. Most of the measures require no more than good record-keeping over a period of time. Internal measures can be calculated annually, while items that more directly impact customers (e.g., *road calls*) should be reported more often—monthly, if possible.

Economic

Due in part to National Transit Database (***1***) reporting requirements and in part to an agency's need to evaluate its financial performance, economic measures were the most widely used measures among the 19 transit agencies interviewed. Economic measures assess how well agency resources are being utilized, how efficiently service is provided within the agency's constraints, how effectively transportation demand is met, and how well the agency is administered.

Because a number of these measures are either reported directly to the NTD or can be derived from other NTD measures, transit agencies already collect and report much of the information required for these calculations. Similarly, because most agencies are required to report to the NTD and, in theory, the measures are reported consistently between agencies, many people comparing transit performance between agencies do so based solely on economic measures. As this Guidebook points out, though, relying solely on economic measures fails to evaluate how well service is provided to passengers and how much benefit the community receives from transit service.

Economic measures generally require only careful record-keeping. *Ridership* is usually reported weekly to monthly, while basic financial measures such as *farebox recovery ratio* and *cost per revenue mile* are reported monthly to quarterly. Other measures typically are reported quarterly to annually.

CAPACITY

Capacity measures reflect the agency's ability to meet existing demand and to determine the ultimate number of people or transit vehicles that can be served by transit facilities. Passenger demand that approaches or exceeds a system's capacity is likely to impact quality of service, as reliability tends to suffer, transit speeds decrease, and passenger loads increase. The TCQSM (2) provides procedures for calculating various aspects of transit capacity and their effects on quality of service.

PARATRANSIT

Paratransit measures overlap the other categories presented above. Measures included in this category are ones that evaluate aspects of demand-responsive service that are not applicable to fixed-route service and measures that must be evaluated to make sure an agency is in compliance with the ADA.

COMFORT

Comfort measures also overlap the other categories. While many of these measures are also service delivery measures, some reflect the quality of the maintenance program, while others reflect noise and other impacts of transit service.

TYPES OF MEASURES

Implementing a performance-measurement program involves a number of trade-offs:

- The number of measures to be reported—too many will overwhelm users, while too few may not present a complete picture.
- The amount of detail to be provided—general measures will be easier to calculate and present, but more detailed measures will incorporate a greater number of factors influencing performance.
- The kinds of comparisons that are desired to be made—will performance be evaluated only internally or compared with other agencies?
- The intended audience—some audiences will be more familiar with transit services and concepts than others.

Several different types of measures exist that can help agencies address these trade-offs, as described in the following sections.

Individual Measures

An individual measure is something that can be measured directly, such as *ridership*, *frequency*, or *number of employee work days lost to injury*. Individual measures are often easy to calculate and explain to users. However, a large number of individual measures may be needed to present a complete picture of transit performance. In addition, some kinds of comparisons can only be made fairly with other types of measures, such as ratios. As a result, most agencies use a combination of individual measures and ratios.

Ratios

Ratios are developed by dividing one individual measure by another, such as *cost per revenue mile*, *vehicle miles per square mile*, or *passengers per seat*. They are generally not much more difficult to calculate or explain than individual measures, and they facilitate comparisons between routes, areas, or agencies. For example, one route may have twice the number of boardings as another route but may also operate twice as frequently. Dividing boardings by the number of vehicles, miles, or hours operated would provide an apples-to-apples comparison of the two routes' relative productivity.

Indexes

Some aspects of quality of service, such as availability, involve a number of different factors. To simplify the reporting of potentially complex measures, some researchers have developed index measures combining results from several other performance measures in an equation to produce a single output measure. Often, the output measure is normalized to fit a 0-10, 1-5, etc., scale for ease of presentation. For example, the *Local Index of Transit Availability* combines measures of capacity, frequency, and route coverage and normalizes them to produce a measure of transit service intensity with values ranging from 0 to 10 (most commonly between 1.5 and 7.5).

Index creation.

Indexes are usually created in one of two ways: by means of an equation that weights different factors based on their importance (determined by judgment, the consensus of a committee, or results from a customer satisfaction survey), or from a regression model that relates an output measure to several input measures.

Index advantages and disadvantages.

The main advantage of indexes is that they minimize the number of measures reported. As a result, a program incorporating several indexes can address a greater variety of issues or goals than can one relying on the same number of individual measures or ratios. The single index measure simplifies presentation.

The disadvantages of indexes are that they cannot be directly measured in the field, may not be particularly intuitive (what does an index value of 2.3 mean?), and may mask significant changes in their component measures. One index factor could improve greatly while another index factor declines greatly, resulting in a minimal change in the overall index.

LEVELS OF SERVICE

Levels of service originated with roadways, but comparable measures have since been developed for most other modes.

The concept of levels of service (LOS) was originally developed by the 1965 *Highway Capacity Manual* (***21***) as a means of simplifying the presentation of potentially complex highway measures and, particularly, to help interpret how travelers perceive conditions represented by a particular performance measure value. Since that time, roadway LOS has become widely accepted around the U.S.; and the concept has been incorporated in measures used by other modes, including transit. The *Transit Capacity and Quality of Service Manual* (**2**) adopted the LOS concept partly because of the familiarity of decision-makers with roadway LOS, allowing transit to take advantage of the success of roadway service measures.

The basic concept behind levels of service is to assign "A" to "F" letter scores (highest to lowest) to specified ranges of values of a particular measure, based on user perceptions of the service quality associated with that measure. In theory, a user should notice a change in service quality as one moves from one LOS range to another. For example, for *frequency*, the TCQSM provides the following comments associated with each level: LOS "A" = passengers don't need schedules, LOS "B" = frequent service, passengers consult schedules, LOS "C" = maximum desired time to wait if bus/train missed, LOS "D" = service unattractive to choice riders, LOS "E" = service available during the hour, LOS "F" = service unattractive to all riders.

Levels of service represent the customer point of view, rather than the agency.

Two things must be kept in mind about levels of service. First, they represent the user (e.g., passenger) point of view, rather than the agency point of view. Very frequent service may be highly convenient for passengers but uneconomical for agencies to provide in all but the highest density areas. These trade-offs are made by the service standards that agencies set; these same kinds of trade-offs are routinely made by roadway agencies when setting roadway LOS standards. Second, although the LOS scores resemble school grades, they should not be interpreted that way. An agency should not necessarily be aiming for "A's" and "B's" but rather an appropriate LOS that balances passenger service quality with agency resources. However, the grades are similar in that LOS "F" should be considered a condition that most passengers would find unacceptable.

LOS advantages and disadvantages.

The advantages of LOS designations are that they simplify the presentation of measures to the public and to decision-makers and provide built-in interpretation about the conditions being measured. The main disadvantage of LOS is that the scores' resemblance to school grades may lead to misinterpretations, if LOS results are presented out of context. The TCRP A-15A project found that one fear raised by transit agencies was that opponents could see "D", "E", and "F" scores and claim that the agency was failing to do its job. However, this situation has not been a problem for roadway agencies, which routinely encounter the same kinds of LOS scores. Also, the LOS ranges mask changes and trends occurring in the underlying performance measure. Consequently, it is recommended that both the LOS score and the associated performance measure value be reported.

DATA SOURCES, DATA COLLECTION TECHNIQUES, AND APPLICATIONS

Many different transit performance measures exist, and the amount of effort required to calculate them varies considerably. However, there are a number of sources of readily available, useful information that agencies have access to that can serve as a starting point for a comprehensive performance-measurement program. This section describes these sources.

In some cases, an agency may require new sources of information, or more detailed information, to assess its achievement of a particular goal. For these situations, this section also describes data collection techniques that require staff or equipment resources the agency may not have on hand, and the relative amount of effort required for those techniques. Agencies can use this information to decide whether the benefit of the data would outweigh the effort required to obtain it.

IN-HOUSE

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 these kinds of data include

- Schedule data,
- System maps,
- Service design standards,
- Demand-responsive service dispatch logs,
- Maintenance records,
- Operations logs,
- Accident and incident records,
- Financial data,
- Fleet data,
- Employee records, and
- Complaint records.

Measures developed using this information require little investment in staff time or resources, as the data are already being collected for other purposes and need only be compiled for use in the agency performance-measurement program.

NATIONAL TRANSIT DATABASE

The Federal Transit Administration requires that all agencies benefiting from Urbanized Area Formula Program (Section 5307) grants report certain statistical information each year. This information is incorporated into the National Transit Database (***1***), which is readily available for agencies, planners, researchers, and others to use to evaluate different aspects of transit service (mostly related to safety and economic performance).

Over 600 organizations currently supply information to the NTD, mainly urban transit systems and private carriers who supply purchased (contracted) service. Organizations operating nine or fewer vehicles in nonfixed-guideway service are exempt from reporting but may voluntarily submit NTD reporting forms.

Examples of the kind of data available from the NTD include

- Service area characteristics (e.g., area and population);
- Agency type;
- Number of vehicles operated in annual maximum service;
- Sources of, and uses for, capital funds;
- Sources of, and uses for, operating funds;
- Labor hours and cost data;
- Overall agency income and expenses;
- Fleet information;
- Rail and maintenance infrastructure data;
- Directional route miles by bus facility type;
- Safety and security incidents;
- Amount of service provided (e.g., vehicle miles, vehicle hours, and days of service);
- Amount of service consumed (e.g., unlinked trips and passenger miles); and
- Energy consumption.

The NTD represents the best national source for transit data for those users wishing to compare measures across agencies. However, caution is required in drawing conclusions from the data, as not all measures have been reported consistently between agencies in the past and different agency objectives will lead to different performance measure results. Blanket conclusions that one agency provides better service than another based on one or a combination of these measures, without considering the context in which each agency operates, are of little practical use.

For individual agencies, the NTD measures represent data that in most cases are already being collected. As with in-house measures, there is little additional investment in time or resources required, other than that needed to compile the measures in the reporting format(s) used by the agency's performance-measurement program.

The Lehman Center for Transportation Research at Florida International University developed software for the Florida DOT to assist in analyzing NTD data and to help select and compare peer agencies. A copy is provided on the accompanying CD-ROM and the most recent version may be downloaded from the Center's web site, at the address shown to the left. Users of the software can also register on the Center's web site to be notified of future software updates.

http://www.eng.fiu.edu/LCTR/Ftis/ftis.htm

Other Agencies

Other local, state, and federal agencies often will be able to supply information on external factors that influence where and how well transit service is provided. The sections below describe some of the kinds of data that may be available.

Demographic Data

The most common kinds of demographic data used by the performance measures described in this Guidebook are population and job data. These data are required for some of the more detailed service availability measures, as well as for some community measures.

Population data can be obtained from the U.S. Census Bureau or from estimates developed by a local metropolitan planning organization or city planning department for use in their local transportation planning model. The number of apartment units, which can provide an estimate of the number of multi-family households, can be obtained from local jurisdictions' building permit or business license data. In states that permit the release of such data, the number of people in certain categories (e.g., licensed drivers) can be determined at an individual address level.

The local transportation planning model may also be a source of employment data. Other agencies that may have employment data include state labor departments, local agencies that issue business licenses, or, in jurisdictions that assess payroll taxes, the local taxing authority.

Population data from the census or a planning model will be aggregations typically covering multiple-block areas (e.g., census blocks, census tracts, or transportation analysis zones [TAZs]). These data may need to be disaggregated into the areas served and not served by transit. GIS software can help in doing this and can also be used to match individual address data to areas served and not served by transit. The section on GIS data discusses specific analysis issues that should be considered.

Traffic Data

Local public works departments and state departments of transportation are sources for information on daily traffic volumes, traffic speeds, sidewalk inventories, traffic signal timing information, and the number of lanes provided on streets. Local planning departments may also have sidewalk inventory data gathered through their long-range transportation planning process. Local community development or public works departments may also have peak-period traffic volumes gathered through routine data collection, the long-range transportation planning process, and/or development impact studies.

Traffic data are needed to measure or estimate values for the following types of measures

- *Mobility*,
- Most travel time measures,
- *Pedestrian and bicycle access* to transit stops, and
- Vehicle and person *capacity* of transit operations in mixed traffic.

GIS DATA

The geographic information systems (GIS) maintained by many planning organizations can be excellent tools for spatially analyzing data. Some transit agencies also have their own GIS systems, including those that use GIS-based scheduling software or automatic vehicle location or automatic passenger counting (AVL or APC) equipment.

The more detailed spatial availability measures, including *service coverage*, *route coverage*, *service density*, *Transit Orientation Index*, *percent person-minutes served*, *Transit Service Accessibility Index*, and *Local Index of Transit Availability*, are all best calculated using GIS software. Similarly, the following community-oriented measures are all best evaluated with GIS software: *demographics, accessibility, welfare-to-work access,* and *service equity.*

Many of these measures assess the number of people and/or jobs located within a certain distance of transit service. However, in most cases, the population and job data are provided for relatively large, multiple-block areas, such as census blocks, census tracts, or transportation analysis zones (TAZs), only parts of which will be within the set distance of transit service. As a result, it is necessary to develop a means to allocate population and jobs in a given area between the portion of the area served by transit and the portion not served by transit. Several means exist to do this:

- The simplest method is to allocate population and jobs based on area. If 60% of an area is served by transit, it is assumed that 60% of the population and jobs are served by transit. This allocation assumes that population and jobs are distributed evenly over the area, which may not be the case but is often adequate for general planning-level system assessments.
- Another method is to allocate population and jobs based on the proportion of street length within the area served by transit, under the assumption that development has occurred when streets have been built. This kind of allocation requires somewhat more work than the first method.
- A more sophisticated method is to combine zoning and/or development information to allocate population and jobs to areas zoned and/or developed for those uses. In effect, each area is subdivided into smaller sub-areas containing only single-family residential, multi-family residential, commercial, office, or mixed uses. Population, for example, would be allocated proportionately to single-family and multi-family areas based on housing densities (from the zoning code) and average household size (from census

data). Once population and jobs have been assigned to the sub-areas, one of the two methods described above could be used to identify how many people and jobs are served by transit. This kind of allocation requires substantially more work and data than the first two methods.

The kinds of population and job allocations described above can be performed in basic GIS packages, when the area served by transit is assumed to be a circle around a bus stop (i.e., an air distance). Depending on the street pattern, this assumption can greatly overestimate the number of people who can actually walk to the stop within the set distance. Also, some areas may be included that are not physically connected to the stop, due to intervening barriers such as freeways, railroads, canals, etc. These areas will need to be manually removed from the transit coverage area.

It is also possible to calculate actual walking paths to transit stops using GIS software; however, this function usually is not provided with entry-level GIS packages. Using walking distances rather than air distances provides a more accurate picture of service coverage and allows users to discard streets with poor or non-existent pedestrian facilities.

Another consideration when using GIS data is accuracy. The authors' experience has been, for example, that up to 25% of the bus stops coded in GIS databases are incorrectly located. The bus stops may have been correctly placed at the time the database was first developed, but subsequent changes are not reflected in the database. Consequently, agencies planning to use GIS data should establish a process to ensure that data are kept up to date and that the datasets used are spatially consistent.

For agencies considering implementing a GIS system, the biggest expense will likely be the labor involved in assembling, validating, and maintaining the data. This expense will vary depending on the size of the system and the availability of local data from other sources. Other expenses will be the purchase of the software itself, a relatively powerful computer to run it on, and staff training. *TCRP Report 60* (**22**) provides details for establishing a GIS system at a transit agency, and GIS's potential uses for welfare-to-work transportation planning and service delivery. *TCRP Synthesis of Transit Practice 34* (**23**) also discusses GIS uses for bus planning and monitoring.

TRANSPORTATION PLANNING MODELS

Transportation planning models are used to forecast how an area's growth and/or new or expanded transportation facilities will affect travel patterns and demands. Outputs from these models can be used to calculate community-oriented measures such as *mobility*, *trip generation,* and *accessibility*; many travel time-related measures; and *demand-to-capacity ratios*.

Four-step transportation planning models.

Transportation planning models divide an area into a number of transportation analysis zones (TAZs) that are generally multiple-block areas with similar land use and transportation access characteristics. Given household and employment data, the model estimates the number of trips *generated* by (e.g., from households) and *attracted* to (e.g., to jobs) in each zone. Next, the trips generated by each zone are *distributed* to other zones, based on a process that considers the attractiveness of the destination zones and a measure of separation (friction factor) between zones (e.g., travel time). The result is a probability that the traveler in an origin zone would travel to a particular destination zone at a particular time. Third, the probability that travelers will choose a particular mode for trips between each pair of zones is based on the relative travel benefits associated with each *mode choice* option. The sophistication of the mode choice process can vary greatly between models. Finally, trips are *assigned* to particular travel paths through an iterative process that considers travel times along alternative paths (***24***).

Transportation planning models can provide the following information:

- Number of trips made by automobile and transit between two zones and systemwide,
- Travel times by automobile and transit between two zones,
- Vehicle-miles traveled,
- Travel speeds along roadway segments, and
- Mode splits (depending on the sophistication of the mode choice model).

The sophistication of the model's mode choice component is important.

The mode choice component of the overall model will often determine the model's usefulness for transit performance measurement. The mode choice model needs to be sensitive to changes in the factors the transit agency is interested in. If the model is not sensitive to service frequency, for instance, its outputs will not reflect any difference in transit ridership due to the increased frequency.

Verify the model's calibration, including transit usage.

Agencies planning to use transportation model outputs should also verify that the model reasonably reflects current conditions on specific transit routes and traffic volumes on key roadways (i.e., model *calibration*). A model that is not well calibrated is of little use.

AVL, APC, AND FAREBOX DATA

Automated systems may help improve data accuracy and completeness, timeliness of reporting, and data collection costs.

As discussed in the next section, manual data collection is labor intensive, but it continues to be the way that many agencies collect ridership, passenger load, and reliability data. Because of the costs involved with manual data collection, only a small number of trips can be sampled. In addition, measurement errors can occur when data are collected or transcribed.

To more accurately collect and more timely report ridership, loading, and reliability data, some agencies have turned to automated or semi-automated data collection. *TCRP Synthesis of Transit Practice 29* (**25**) and *TCRP Synthesis of Transit Practice 34* (**23**) provide details about these methods; some key points are covered within this section. The TCRP H-28 project, when completed, will provide guidance on collecting and managing AVL and APC data.

It is common among agencies that adopt these automated collection methods to go from not having enough data to being overwhelmed by it. The decision to use an automated data collection method should include serious consideration of how the data will be stored and managed.

AUTOMATIC VEHICLE LOCATION

AVL equipment can serve two main functions:

1. To track the real-time location of AVL-equipped buses for use in dispatching, real-time bus arrival information, responding to emergencies, etc., and
2. To collect and store data about bus arrival and departure times at specified locations.

The first function requires a more extensive system, typically requiring AVL equipment on all buses and a central control center. Agencies would normally buy the equipment and hire and train the additional staff. This kind of system may also be able to collect and store data for all trips made by all buses. However, because of bandwidth issues, a system designed to transmit data from buses to a central location will not be able to transmit as much data as one where the data are stored on the bus and transferred later to a central database. Also, the intervals at which the control center requests ("polls") a given bus' position are relatively long (e.g., 90 seconds). Because the control system (and thus subsequent stored data) does not know where the bus is between polling events, it is difficult to get accurate time information for specific locations. (**23**) Many performance measures that could benefit from AVL data require knowing accurately when buses arrive and depart from specific locations (as opposed to knowing accurately a bus' position at the time it is polled). AVL systems that use polled data may still be able to provide basic running time data but will do so less accurately and require greater levels of manual analysis than systems that can match arrival and departure times to specific stops.

Agencies requiring only the second function often choose a less extensive system in which selected buses are equipped with AVL equipment. These buses are rotated among different runs, allowing, for instance, each run to be sampled once a month. Data are stored on the vehicle, allowing exact arrival and departure times to be recorded. Agencies may purchase the equipment and conduct data analyses themselves or may choose to lease the equipment from an outside vendor, who may also provide data analysis services.

Some AVL systems, such as those used by TriMet in Portland, Oregon, and by Calgary Transit in Canada, serve both functions: they provide bus position information to a central control center and store extensive data about bus locations on board each bus.

AVL systems that record exact arrival and departure times are capable of producing the kinds of data listed below. Systems must be programmed to record the kinds of information desired. Differences in definitions of arrival and departure times (e.g., arrive in the stop vicinity vs. door opening time) may affect the usability of the data for comparisons between agencies. Potential data outputs include

- Arrival and departure times at stops;
- Dwell times at stops;
- *Travel times* and *speeds*;
- *Travel time variability* between days, times of day, and different operators;
- *On-time performance*; and
- *Headway adherence*, when a series of buses are AVL-equipped.

Some AVL systems also allow bus operators to press a button to indicate particular events that occur at a location, such as a wheelchair boarding or usage of the bicycle rack.

The literature did not identify any accuracy issues associated with AVL systems based on global positioning system (GPS) technology, other than the possibility of signal loss in downtown areas, due to tall buildings. Other technologies, such as roadside transponders and bus odometer monitors, determine the bus' position less reliably the farther the bus gets from a known location and may not provide useful information for a given trip if the bus must detour from its normal route.

TRAIN CONTROL SYSTEMS

The systems used by rail transit operators to maintain safe separation between trains may be able to provide the same kinds of information as listed above for bus AVL systems. Train control systems based on fixed signal blocks know only a rough indication of train location (i.e., the train is located somewhere within the block). However, since block boundaries are usually placed at station exits, it may be possible to identify train departure times and headways from fixed-block systems. Other types of train control systems that provide two-way communication between the train and the control system provide much better location and speed information. Automatic train control systems, which can govern when doors open and close, can be used with both fixed- and moving-block signal systems and will be able to provide detailed dwell-time information.

Commuter rail operations can use dispatching records from centralized train control systems or data from global positioning system (GPS) transponders to obtain on-time performance, headway, and speed information.

AUTOMATIC PASSENGER COUNTERS

APC equipment automates the collection of passenger boarding and alighting data, potentially saving labor costs for manual ride checks and allowing both system- and route-level ridership data to be available more often. APC systems incorporate some form of AVL system, so that the number of people getting on and off at individual stops can be recorded.

Almost always, only a portion of the buses in a fleet will be APC-equipped. These buses will be rotated so that, typically, each trip will be sampled once a month. Agencies surveyed for *TCRP Synthesis of Transit Practice 29* (***25***) reported that about 75% of the sampled trips, on average, resulted in usable data. Some agencies also reported that it took some time to perfect how the APC-equipped buses were rotated among routes to achieve the desired amount of sampling.

Potential data that can be output or derived from APC systems include

- Stop, route, and system-level ridership;
- Maximum passenger loads and their locations;
- Passenger miles;
- How long standing loads occur during a trip; and
- How often loads exceed a pre-determined level.

Different APC technologies exist (e.g., infrared beam, treadle mats, etc.), and all are subject to errors to one degree or another. Potential sources of errors include general equipment malfunction, tendency of individual units to over- or under-count, failing to identify the correct stop, failing to identify the start of a new trip, and operator error when signing on and entering route and driver information (***23***).

ELECTRONIC FAREBOXES

Data from electronic fareboxes are often used to obtain route- and system-level ridership. Because these fareboxes, when used, are typically installed on the entire fleet, it is possible to get regular, large-scale ridership information from them, rather than the ridership samples that other methods generally provide. As each passenger boards, the operator presses a button on the farebox to indicate the kind of fare paid. Adding up the number of each type of fare paid provides ridership. Alternatively, the farebox may be able to determine and automatically record what kind of fare was paid, particularly if magnetic cards are used, minimizing the need for operator input. Buttons can also be used to indicate other kinds of events, such as a wheelchair boarding.

Potential for analyzing trip patterns.

Newer fareboxes can record additional information, such as the time the fare was paid and the unique identification number associated with each magnetic farecard. The latter provides information about how often individual passengers travel and information about linked trips (trips involving one or more transfers) (***23***). If integrated with an AVL system, trip pattern data potentially could be obtained from magnetic farecards. The locations where each farecard was used to board a transit vehicle would be known. If it is assumed that the boarding location for one trip was the alighting location for the previous trip, information would be available on the locations of both ends of the trip.

Potential sources of data errors arising from electronic fareboxes include (**23**)

- Operator failing to register a boarding, pressing the wrong button, or failing to clear the coin box after a non-standard fare;
- Operator failing to sign on properly or to register the start of a new trip;
- Maintenance staff failing to download data each night, resulting in data assigned to the wrong date or being lost due to a shortage of memory;
- Ambiguous assignment of buttons to fare categories; and
- Hardware and software problems.

Staff at the Capital District Transportation Authority in Albany, New York, who were interviewed during the development of this Guidebook, indicated that CDTA bus operators required a period of training on the electronic fareboxes before the data could be relied upon. *TCRP Synthesis of Transit Practice 34* (**23**) reports that the agencies interviewed for that project often had difficulty integrating farebox data with data from other sources. These difficulties hindered these agencies from developing various performance ratios that combined measures based on farebox data with measures developed from other data sources.

Smart cards.

Some larger agencies and consortiums of agencies are implementing smart cards (i.e., plastic cards with embedded computer chips). These cards offer the same potential for analyzing trip patterns as do magnetic farecards with unique identification numbers, which were described above.

Some agencies (such as Washington, DC's WMATA) allow passengers to register their smart cards. A passenger benefits by being able to replace the value on a lost or stolen card, less a handling fee, since the fare collection system can be programmed to reject the missing card. From a performance-measurement standpoint, the agency also benefits because it can match the card to a particular home or business address and can track the travel patterns of people living in different portions of the community (subject to confidentiality requirements). Magnetic farecards usually are not registered to individuals and therefore do not provide the same opportunity for evaluating travel patterns.

MANUAL DATA COLLECTION

Ridership and schedule reliability information are frequently collected manually. Information collected this way will be less extensive than that collected by automated means but is often sufficient for an agency's purposes. Three main types of data collectors are used (**23**)

- *Operators*—Bus operators note the number of people getting on and off at a particular location. This is regular practice for demand-responsive systems and frequently occurs with smaller fixed-route systems where the passenger volumes are relatively light, but is infrequently done by larger systems. Ridership and passenger load data can be determined.

- *Traffic checkers*—Permanent or temporary staff ride transit vehicles ("ride checks") or stand at a location ("point checks") and record data. Traffic checkers are frequently used by medium and large fixed-route systems. Checkers can record arrival times, passenger boarding and alighting volumes, passenger loads, dwell times, and fare payment types (although not all at the same time), from which can be calculated various ridership, loading, and service reliability measures. Checkers may also be used to distribute on-board surveys on travel patterns or other topics of interest to the agency.

- *Field supervisors*—Supervisors record the arrival time of transit vehicles, from which *on-time performance* and *headway regularity* measures can be calculated. When operations problems occur, field supervisors typically work to solve the problem rather than record data; consequently, data collected by supervisors may reflect only normal operations (**2**).

The literature indicates that manual data collection generally produces minimal measurement errors. However, because a limited number of samples are collected, it is subject to sampling error on a route-level basis, where the data collected on a single day may not be representative of conditions in general (**23**).

Passenger environment surveys are another form of manual data collection; these are discussed separately later in this chapter.

Customer Satisfaction Surveys

Customer satisfaction surveys are a valuable tool for learning about what matters to the customers of a particular agency. As discussed in Chapter 2, most transit agencies do not have the resources to conduct the same level of customer satisfaction surveying as do other service industries in the private sector. However, larger systems often have the resources for annual surveying. Smaller systems that may not be able to survey very often may still find it valuable to conduct a customer satisfaction survey when developing a performance-measurement program. The results of the survey can be used to develop performance measures that evaluate the issues that matter to customers.

The process of conducting customer satisfaction surveys requires a more detailed treatment than was afforded other data collection techniques in this chapter. Appendix A provides an overview of customer satisfaction surveying. Detailed information on measuring customer satisfaction is provided in *TCRP Report 47* (**4**).

SAFETY REVIEWS

http://transit-safety.volpe.dot.gov/

Safety reviews or audits should be used on a regular basis to catch potential safety problems before they result in an incident. These reviews do not generate the same kinds of performance measures as other data collection techniques described in this section. Rather, the reviews consist of a number of yes/no questions, with the preferred answer "yes," indicating that a particular safety aspect (e.g., regular brake inspections) is being addressed. The FTA Office of Safety and Security and state agencies regulating the safety of passenger transportation can provide information on conducting safety reviews.

PASSENGER ENVIRONMENT SURVEYS

Passenger environment surveys are used to track transit cleanliness and ride comfort. Surveys also provide information that is difficult to measure by other means but which plays an important role in how passengers perceive transit service quality. These surveys are best conducted using a dedicated staff of surveyors and may not be feasible for smaller systems with limited resources. However, larger systems may have the resources to conduct these surveys and may find the results of the surveys quite beneficial.

The process of conducting passenger environment surveys requires a more detailed treatment than was given other data collection techniques in this chapter. Appendix B provides an overview of the process of passenger environment surveys, including examples of two agencies' programs.

DATA MANAGEMENT

The data collected through a performance-measurement program needs to be organized for analysis, reporting, and archiving. The sophistication of the system that is required will depend on the amount of data collected, which in turn depends on the agency size and the number and kinds of measures collected. A simple spreadsheet may be adequate for rural and small urban systems, while a more sophisticated database will likely be needed for a medium-sized system. Larger systems may require an information management system to integrate data collected and maintained by various agency departments. *TCRP Synthesis of Transit Practice 5* (**26**) describes the kinds of information systems used by different U.S. transit agencies and issues to consider about them.

SETTING PERFORMANCE STANDARDS

When performance measures are linked to agency goals, as recommended by this Guidebook, performance standards should be established for each measure. These standards are used to determine whether or not each goal is being accomplished.

The standards chosen should be neither unrealistic, in which case the usefulness of the entire program will be called into question, nor too easy to achieve, in which case agency performance is unlikely to improve. Brown (*8*) states that standards should be "challenging, worthwhile, and achievable." Standards should require work to achieve; but the benefit derived should outweigh the cost of achieving the increased performance, and the goal should not be set so high that it can never be reached.

Implementing performance standards through design standards.

When design standards are followed, agencies can be confident that the goals related to those standards are being met, without having to regularly track those measures.

Some standards can be implemented as design standards. If the design standard is being met, the agency can be reasonably confident that the goal related to that standard is being met. This saves the agency the need to regularly track the measure related to that goal, as long as it takes care to ensure that the design standards are followed.

For example, MDTA in Miami, Florida (*27*), developed four categories of measures: (1) economic and service performance measures, which are evaluated on a regular basis; (2) service planning guidelines, which specify policy headways for specific service types at different times of day; (3) bus route design standards, which are used in evaluating whether routes need to be introduced, combined, split, or terminated; and (4) new service guidelines, which provide criteria for deciding whether a new route would be appropriate in a given area. As a result, three of MDTA's four categories of measures do not require regular measurement, but still ensure that the agency's goals in those areas are being met.

As another example, the Chicago Transit Authority (*28*) has adopted standards that relate bus headways to demand and passenger loading. As demand increases on a route, headways are reduced to achieve a desired average load. High-frequency routes are allowed to have higher average loads than low-frequency routes, representing a trade-off between passenger convenience (frequent service), passenger comfort (the possibility of having to stand), and agency resources (the number of buses required to serve a route).

As a final set of examples, the Champaign-Urbana Mass Transit District operates services to the University of Illinois that have distinct differences from the non-university services in ridership and other characteristics. The agency currently applies one set of standards to all services, but agency staff recognize that the standards would be more effective if they were differentiated between the two types of services. The Denver RTD and the Maryland MTA are agencies that have implemented different standards for different service types.

Developing standards for measures that are tracked regularly.

There are six main methods that agencies use to develop standards for measures tracked regularly (e.g., weekly to annually), as described in the following sections.

COMPARISON TO THE ANNUAL AVERAGE

Under this system, the average value for each measure is determined annually, and the routes that fall into the lowest (and sometimes highest) groups for each measure (e.g., lowest 10th percentile, lowest 25th percentile) are identified for further action. For systems with limited resources, this allows the agency to focus its actions toward the poorest-performing routes.

The drawbacks of this method are that there is no connection between the standards and customer satisfaction, nor is there any identification of how well the system as a whole is operating. All of an agency's routes could be performing well in a given area, from the passengers' perspective. Identifying the lowest 10% of routes in this situation likely would be unproductive. Conversely, an agency could have system-wide problems meeting a particular goal. In this case, targeting only the worst-performing routes would fail to address the system-wide issues leading to poor performance.

COMPARISON TO A BASELINE

This is a variation on the system described above, comparison to the annual average. In this case, the value for each measure is compared to the average value for the measure in the first year that the performance-measurement system was implemented. (Some systems adjust their baseline values for financial measures to account for inflation.) Measures that fall below a certain percentage of the baseline value are targeted for further action.

This system is an improvement on comparison to the annual average, as it allows current performance to be easily compared to the baseline and focuses attention only on those areas that are truly under-performing (i.e., if all routes are performing better than the baseline for *boardings per revenue hour*, for example, there is no need to take time identifying the lowest 10% of them, as no action would need to be taken under this system).

As with the first system, there is no connection between the standards and customer satisfaction. There are two additional drawbacks. There is no incentive to improve—simply maintaining the baseline condition is more than sufficient to meet the standard. Finally, this method requires that the baseline condition be adequate; otherwise, the performance standard could be met but not the goal that the standard relates to.

TREND ANALYSIS

Another option is to set the standard based on the previous year's performance measure value. In this case, the standard would be expressed as "improvement from the previous year" or "x% improvement over the previous year." (If performance dropped the previous year, the previous year's standard would be retained and not lowered.) Measures that show worsening performance, compared to the previous year, would be targeted for further action.

The advantage of this method is that incentives are built into the method to achieve continually improving performance and to track performance trends over time. Disadvantages include no direct relationship between the standards and customer satisfaction and a potential to greatly increase the number of measures that require follow-up attention, if performance slips system-wide from one year to the next. Also, it must be recognized that at some point it becomes cost-ineffective to try to continue to improve performance in a particular area; in these cases, the standard should be to maintain the existing high level of performance.

When the standard is "x% improvement," the value of "x" would be set by transit management and/or the agency's governing body in the same manner as described for the next method below.

SELF-IDENTIFIED STANDARDS

Under this method, transit agency management, often in consultation with the agency's governing body, sets targets based on a combination of current agency performance, professional judgment, and agency goals. This method allows customer and community issues to be considered and, if the standards are updated on a regular basis, allows for continual performance improvement. This method allows standards to be directly tied to customer satisfaction, particularly when the results of a customer satisfaction survey are available to determine the level at which customers are satisfied or very satisfied.

One potential flaw with this method is that the experience of other agencies is not taken into consideration. Eccles (***29***) states that comparing one's performance to other similar organizations can produce more of an eye-opening effect than simply comparing one's own historical performance.

COMPARISON TO TYPICAL INDUSTRY STANDARDS

This method builds on the work done by other agencies, under the principle that "if it's good enough for the other guy, it should be good enough for us." The agency surveys other representative agencies or finds examples of standards in the transit literature (such as this Guidebook) and applies an average or typical standard to its own operations.

This method has the advantage of being at least somewhat defensible—the standards were not pulled out of thin air, but are comparable to what others are doing—but it fails to consider either other agencies' special circumstances that caused them to adopt a particular standard or the agency's own circumstances.

The method can be useful for identifying if existing standards, or ones being considered, are considerably higher or lower than those of other agencies. A considerably higher standard may indicate that it is being set unrealistically high, while a standard that is considerably lower than others may indicate that it has not been set high enough.

When comparing other agencies' standards, it is important not only to identify the standard itself but also any definitions used to develop the performance measure. An example is *on-time performance*. Results will be higher if up to 10 minutes late is considered "on-time" than if no more than 5 minutes late is considered "on-time." Accordingly, an agency using the first definition of "on-time" may set a higher on-time percentage as its standard than an agency using the second definition. However, these different definitions frequently are not reported, making it difficult to compare two agencies' standards.

COMPARISON TO PEER SYSTEMS

Under this method, an agency identifies other agencies with similar conditions (e.g., city sizes, level of government support, fare levels, goals and objectives, cost of living index values, or other similar criteria), and determines how well those agencies are performing in the measurement categories. Standards are based on the average values of the peer agencies for given measures, or alternatively, some percentile value.

This method has the advantage of providing a realistic assessment of where an agency may have room for improvement and the ranges of performance that are being achieved by its peers. However, it requires up-front work to identify peer agencies, and both up-front and ongoing work to track performance measure results from the selected peer group. Also, not every selected peer agency may track performance in the areas that the agency setting standards is interested in.

The Florida Transit Information System (FTIS) software developed by Florida International University for the Florida DOT can be used to help identify potential peer agencies. However, it does not replace the need to follow up with potential peers to identify areas of differences that could influence comparisons between agencies. A copy of the software is included on the accompanying CD-ROM; the most recent version can be downloaded from the FTIS web site at the address shown to the left.

http://www.eng.fiu.edu/LCTR/Ftis/ftis.htm

RECOMMENDATIONS

A combination of the methods described above is ideal. Developing a baseline and tracking performance each year provides useful information on whether changes in a measure represent trends or 1-year statistical blips. Comparing performance to peer agencies will indicate areas of excellence or deficiency. Internal review of standards allows local conditions and objectives to be considered and should be done annually to encourage continued improvement in areas where improvement is still feasible.

One size may not fit all when developing standards. Consider adopting standards that vary by service type and time of day.

An agency should strongly consider developing different standards for different types of services and different times of day. The Champaign-Urbana MTD identified separating university services from other types of services as a need for its program. The Denver RTD identified seven classes of service (local-CBD, local-urban, local-suburban, express, regional, demand-responsive, and airport). Miami's MDTA set different performance standards by different times of day (peak, base, evening/night, and Saturday/Sunday).

The Livermore Amador Valley Transit Authority conducted a thorough examination of the performance measures utilized throughout the industry before setting up its program in 1998. Based upon this review, LAVTA agreed upon nine separate performance measures intended to address the system's ability to provide reliable, economical, efficient, and safe transit services. LAVTA also established target values for each of these performance standards, which allows the system to evaluate its performance in each fiscal year as either "meeting the standard" or "not meeting the standard."

REPORTING RESULTS

Performance results will be reported to different groups of stakeholders. These groups may include operating personnel, senior managers, the general public, members of the agency board, political officials, and officials in other agencies. Results should be reported to each target audience in a manner appropriate to that audience. Otherwise, the intended message and usefulness of the performance measures will diminish.

Operating personnel need reports that are diagnostic in nature and provide as much detail as possible. The optimal frequency of reporting is probably much higher for operating personnel than for the general public. With the enormous amount of information and data that may be obtained from AVL and APC systems, statistically valid results may be obtained for short time intervals for a wide array of service and maintenance measures. These results may then be used by operating personnel to make real-time improvements to the transit service.

Senior managers need reports that are less detailed, while the members of the board and officials may desire reports that are even less detailed. While level of detail should decrease, these stakeholders' breadth of responsibility for various elements of transit service increases. The general public (including transit customers) needs information and results conveyed in a clear, understandable manner. Figure 7 illustrates the relationships between stakeholder responsibility and amount of detail.

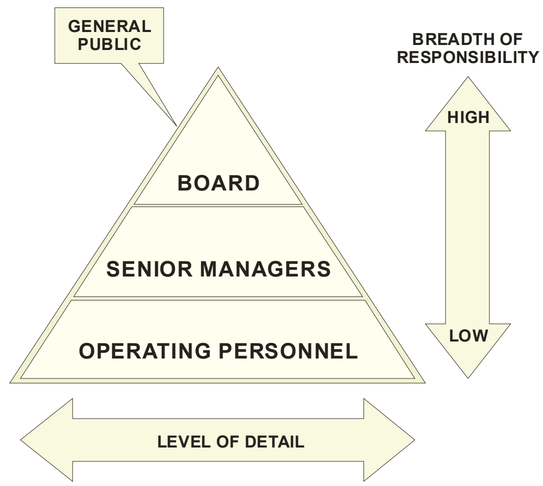


Figure 7. Agency Stakeholder Reporting Needs

As the amount of detail provided decreases and the breadth of measures increases, it becomes more important to consider how the information is presented to its intended audience. One-page summaries, such as the Federal Transit Administration's NTD agency profiles (***30***) or the example from BART shown in Figure 8 convey a broad range of information in a visually appealing way and use a minimum of space. These kinds of reports can be set up in a spreadsheet and can update themselves as new information is provided each reporting period.

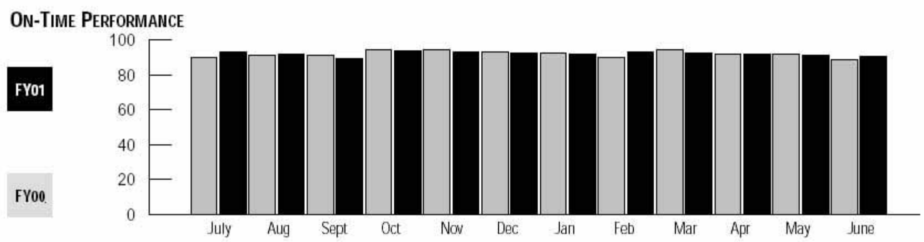
Reports intended primarily for the public rely more on graphics to present results and typically report a small number of measures. Interpretation of what the graphs mean is often incorporated into the report design, along with limited trend information (often a comparison with the previous year). Figure 9 shows examples of graphics-based reporting of several key measures and a text-based agency report card. Figure 10 shows an example of customer satisfaction reporting.

Measures used internally may be more detailed than those reported to the public or decision-makers, but the need for clear presentation is no less important. Managers need to be able to easily identify key performance trends. Figure 11 shows an example of a graphical presentation of a single performance measure, including a trend line, individual monthly measure values, and a comparison to the agency goal for that measure. Figure 12 shows a number of measures presented in the form of a table. Bold type and boxes are used to highlight where goals were achieved and which measure improved from the previous quarter.

PERFORMANCE HIGHLIGHTS • FY 2001 & 2000

	2001	2000
Rail Ridership		
Annual passenger trips	97,280,846	91,092,289
Average weekday trips	331,586	310,268
Average trip length	12.99	13.00
Annual passenger miles	1,263,667,796	1,184,106,267
Daily train on-time performance	92.2%	92.1%
System utilization	31.5%	29.9%
End of Period ratios		
Peak patronage	58%	57%
Off-peak patronage	42%	43%
Operations		
Annual revenue car miles	58,771,224	57,377,586
Passenger accidents/million passenger trips	5.40	7.13
Passenger crimes/million passenger trips	48.17	45.76
Financial		
Net passenger revenue	$ 213,259,843	$ 194,291,205
Other operating revenue (excluding net change in fair value of investments)	$ 24,073,478	$ 18,806,592
Total operating revenue	$ 237,333,321	$ 213,097,797
Net operating expense (excluding depreciation)	$ 334,083,541	$ 314,798,648
System farebox ratio		
Net passenger revenue/net operating expense	63.8%	61.7%
System operating ratio		
Total operating revenue/net operating expense	71.0%	67.7%
Net rail passenger revenue/passenger mile	$ 0.168	$ 0.164
Rail operating cost/passenger mile	25.3¢	25.7¢
Net average rail passenger fare Including FastPass	$ 2.19	$ 2.13

Notes:
1. FY01 system utilization reflects July 2000 through December 2000 date.
2. The peak period was expanded in FY00 to include a three-hour am and three-hour pm time period. Previously, a two-hour am and two-hour pm period were reported.



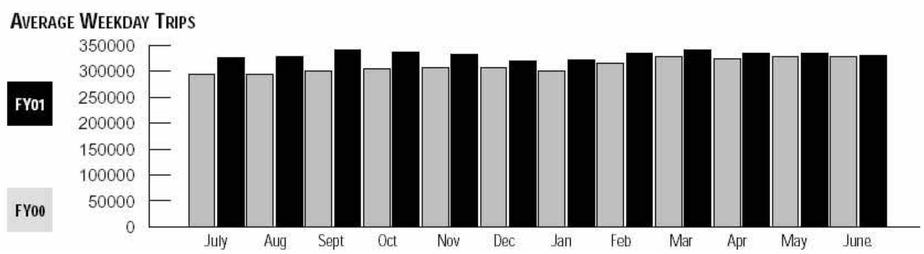
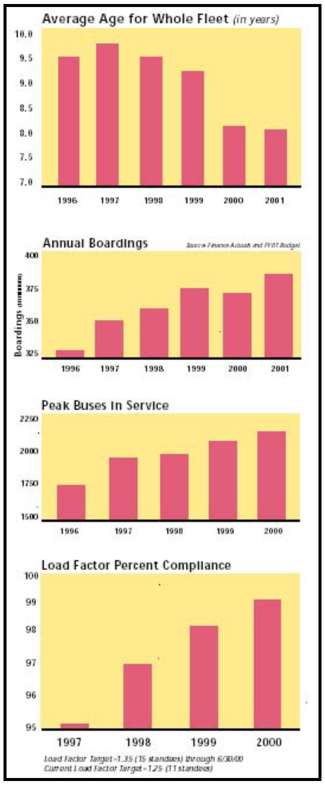


Figure 8. One-Page Summary Report Example (*31*)



RTA Report Card

- Ridership[1]
  - 29,333,600 customers served in 1st six months of 2001
  - 29,779,300 customers served in 1st six months of 2000
  - 1.5% lower
- Traffic Safety[2]
  - 0.92 vehicle collisions per 100,000 miles in 1st six months 2001
  - 0.99 vehicle collisions per 100,000 miles in 1st six months 2000
  - 7.6% improvement
- Complaints[3]
  - 1,726 complaints received in 1st six months 2001
  - 1,802 complaints received in 1st six months 2000
  - 4.2% improvement
- Commendations[3]
  - 297 commendations received in 1st six months 2001
  - 303 commendations received in 1st six months 2000
  - 2.0% lower
- On-time Performance[4]
  - 59% on-time during twelve months ending June 2001
  - 57% on-time during twelve months ending June 2000
  - 3.5% improvement

1 The category "customers served" refers to total passenger boardings, is based on farebox receipts and other data, and may be factored.
2 "Vehicle collisions" includes preventable operator-reported incidents in which an RTA vehicle collides with another vehicle or object. Excludes paratransit. "Miles" includes scheduled bus miles adjusted for special service additions and lost trips. It also includes rail mileage that is actual total car miles.
3 Complaints and commendations are received and logged by Customer Service Center via phone, mail, walk-in, or email. Does not include "Ride Happy or Ride Free" requests.
4 This category is based on randomly sampled time points on randomly sampled runs. "On-time" is defined as departing from zero minutes before to five minutes after scheduled departure time. Excludes paratransit. Bus and rail on-time performance may each differ from the composite shown.

August 8, 2001

Figure 9. Public Performance Reporting Examples (*32, 33*)

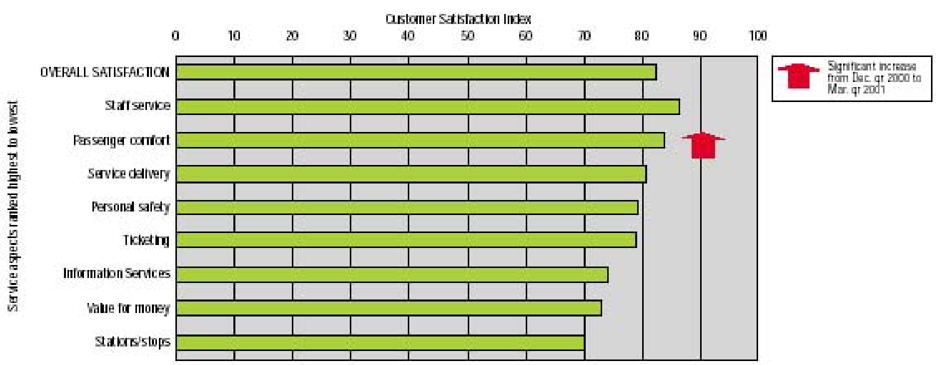


Figure 10. Customer Satisfaction Reporting Example (*34*)

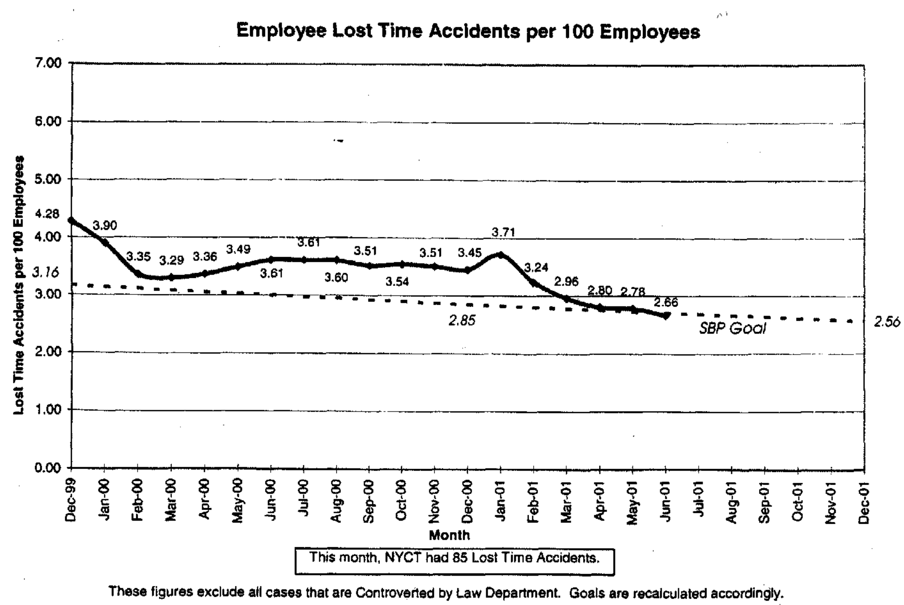


Figure 11. Trend Analysis Example (35)

Scheduled Hours of Service and Equipment that are Delivered							
Mode	**2nd Q % Op Avail.**	**2nd Q % Equip Avail.**	**2nd Q Total Avail.**	**3rd Q % Op Avail.**	**3rd Q % Equip Avail.**	**3rd Q Total Avail.**	**Goal**
SYSTEM WIDE	95.48%	**99.31%**	94.79%	95.89%	**99.72%**	95.61%	
MOTOR COACH	96.32%	**99.15%**	95.46%	96.46%	**99.89%**	96.32%	
Flynn	94.99%	**98.90%**	93.90%	94.75%	**99.61%**	94.36%	
Woods	95.85%	**98.74%**	94.59%	96.07%	**99.91%**	95.98%	
Kirkland	**98.09%**	**99.93%**	**98.02%**	**98.42%**	**100%**	**98.42%**	96.5%
TROLLEY COACH	95.80%	**99.96%**	95.76%	96.10%	**99.99%**	96.09%	
Potrero	94.26%	**99.98%**	94.25%	95.93%	**99.98%**	95.91%	
Presidio	**97.61%**	**99.93%**	**97.54%**	96.31%	**100%**	96.30%	
LRV	93.32%	**98.16%**	91.48%	94.57%	**98.46%**	93.03%	
CABLE CAR	90.75%	**99.89%**	90.64%	91.75%	**99.79%**	91.54%	

Bold = Goal Achieved
☐ = Improvement from 2nd Q

Figure 12. Table Presentation Example (36)

DISSEMINATING RESULTS

There are two main considerations in disseminating results: the timeliness of the reporting and the means of distribution.

The sooner results are available from the performance-measurement program, the sooner managers can identify any problems to correct or successes to replicate. In an interview for this project, Los Angeles County MTA staff noted that "executive management lives and breathes by the performance reports" and that "what gets measured, gets attention." If for some reason one of the reports is late, managers contact the Transit Operations Support department to inquire about it. The results of the reports are an essential part of LACMTA's decision-making and operations—they are incorporated in "management action plans, strategic plans, and literally everything in operations."

The audience for a particular report will often dictate the dissemination method. For transit board members and public officials, a traditional report with an executive summary may be most appropriate. Information can be distributed to passengers via agency newsletters; some European agencies also use advertising displays on station platforms to display performance results. The Internet is another way to distribute information to both passengers and the general public. Employee newsletters and bulletin boards are means of disseminating performance information to agency staff. For senior managers, e-mail may be an efficient way to transmit performance results.

— 6 —

TRANSIT PERFORMANCE MEASURE MENUS

This chapter provides an extensive collection of performance measures (130 families of measures and over 400 individual measures) as a reference for agencies developing or updating a performance-measurement program. Because agencies would be expected to incorporate only a small number of measures into their programs, several methods have been provided to help quickly identify appropriate measures.

CHAPTER ORGANIZATION

The majority of this chapter consists of summaries of individual performance measures (indicated by a ◆ symbol next to their names) and families of measures containing several related performance measures (indicated by ❖). Although these summaries are not intended to be an exhaustive list of every transit performance measure ever developed, they do represent a reasonably comprehensive cross-section of measures that are currently used in the transit industry or that address the kinds of customer- and community-oriented issues that were the focus of this project.

Users should note that the inclusion of a particular measure in the summaries should not be construed as an endorsement of that measure. A conscious decision was made to include summaries of both good and not-so-good examples of performance measures to help agencies identify potential flaws with measures they currently use and, if desired, replace those measures with suitable alternates. Users should carefully review the *assessment* section of each summary to identify potential issues with each performance measure.

The information categories listed below are used in the performance measure summaries. Not all of these categories will appear for every measure:

- *Measure name and type.* The name of the individual measure or family of measures. Some measures have more than one name or variation; these are indicated in parentheses as part of the measure name.
- *Measure summary.* A one-line description of the measure.
- *Focus.* Measures are assigned to particular categories (e.g., availability) and sub-categories (e.g., spatial availability). The focus identifies the specific sub-category the measure is assigned to.
- *Other Uses.* Secondary categories that the measure relates to. This information only appears when secondary categories exist for a given measure.
- *Examples.* This information is provided only for families of related measures (e.g., *road calls*). It lists the individual performance measures contained within the family of measures (e.g., *number of*

road calls, miles per road call, road calls per month per bus/bus model/failure type).

- *Modes.* The transit mode(s) that the measure applies to. "All" indicates that the measure is generally applicable to any transit service.
- *Scope.* The transit system element(s) (e.g., stop, route, and system) that the measure applies to.
- *System Size.* The transit system size(s) that the measure is best suited for. "Any" indicates that the measure is generally applicable to any size transit system.
- *Audience.* A list of likely users of the measure (e.g., decision-makers, transit management, and maintenance staff).
- *Description.* A detailed description of the measure(s). When appropriate, the calculation or weighting methodology is described. Measures that are simply ratios of two other measures (e.g., cost per vehicle hour) are not provided with calculation methodologies.
- *Example target values.* These are examples of (1) actual service standards used in the U.S., (2) sample performance measure results from U.S. agencies, and/or (3) level of service ranges from the *Transit Capacity and Quality of Service Manual* (2). Where information was not available, this category was omitted.
- *Major factors.* A list of factors that influence a given performance measure's result. To improve the measure's result (and thus overall agency performance), users should develop actions that target these factors.
- *Data requirements.* A list of the kinds of data needed to calculate a measure and a description of the level of effort required to calculate it. Refer to Chapter 4 for specifics on particular data collection methodologies.
- *Assessment.* An assessment of the measure's usefulness.
- *Comments:* Supplementary information about a measure is provided in a comment. For most measures, the assessment provides sufficient information and no comment is provided.
- *Reference:* When a measure is specific to one or two sources, a reference section is provided identifying those sources. Generic measures (e.g., boardings per mile) are not referenced. Example performance measure values and other similar information taken from the literature are referenced in the text where they occur and are not listed in the references section.

Documents listed in a measure's "References" section provide more information about that measure.

Information on how often to calculate particular types of measures was given in Chapter 5 and has not been routinely repeated in the performance measure summaries; however, some measure assessments do include this information, where appropriate.

The measures are organized by categories, with a complete list of categories and their associated families of measures presented following the individual summaries. An index of all of the measures included in this chapter is located at the end of the chapter.

The following abbreviations are used in the summaries without explanation:

- ADA: Americans with Disabilities Act
- APC: automatic passenger counter
- APTS: advanced public transportation systems
- AVL: automatic vehicle location
- DOJ: Department of Justice
- GIS: geographic information system
- HCM: *Highway Capacity Manual*
- ITS: intelligent transportation systems
- LOS: level of service
- MPO: metropolitan planning organization
- NTD: National Transit Database
- O-D: origin-destination
- PMT: person (passenger) miles traveled
- TANF: temporary assistance for needy families
- TAZ: transportation (traffic) analysis zone
- TCQSM: *Transit Capacity and Quality of Service Manual*
- VMT: vehicle miles traveled

INSTRUCTIONS

Three methods are provided to help users quickly find a measure appropriate to their needs and resources:

1. *Selection menus* are designed to match specific performance measures to agency goals, modes operated, and/or area population. Users answer a series of increasingly focused questions that serve to narrow the search to a particular measure that matches the user's needs.
2. *Browsing by category* allows users to compare several related measures and then independently decide which one best meets their needs.
3. *Searching by individual measure* is useful for reviewing measures that are currently used in a performance-measurement program. The individual measure descriptions point out potential issues or flaws associated with those measures; if an existing measure has flaws, users may wish to consider alternative measures.

USING THE SELECTION MENUS

The selection menus are a series of tables designed to help users quickly find a measure relating to a particular goal, mode, or system size. At each step in the process, users narrow down their search to an increasingly small number of choices. Usually, users will work through four or five questions to arrive at a measure.

To begin, start with Menu 1 on page 157, which is duplicated below:

Menu 1	**START HERE**	**How would you like to look for a measure?**
By goal	Menu 2	Page 157
By system size	Menu 3	Page 157

To find a measure corresponding to a particular agency goal, proceed to Menu 2, located on page 157. When using the electronic version of this Guidebook, click on the highlighted "Menu 2" text to jump to that menu. Similarly, to find measures suitable for a particular system size or a peer analysis, go to Menu 3.

The new menu will help narrow the search by, for example, listing particular types of goals and then directing the search to a menu corresponding to a selected goal. The process continues through one or two more menus until the user is directed to summaries of candidate performance measures. When a menu provides several candidate measures, the ones most likely to meet an agency's needs are listed first.

Searching for a measure by goal provides access to every performance measure summarized in this Guidebook. In contrast, searching by system size narrows the search to a more limited number of measures. Specifically, the choices presented for a particular system size reflect staff and resource constraints for a typical system of that size. The smaller the system, the fewer the recommended measures to use. The choices given for a peer analysis reflect measures for which data are likely to be available for most systems and which are more likely to be measured consistently. Depending on the kind of analysis to be conducted, additional measures might be necessary; but care should be taken to ensure that different agencies' measures are calculated similarly.

The performance measure summary descriptions provide information about whether a particular measure is suitable (or not suitable) for a given mode. In addition, measures suitable for both general and ADA demand-responsive service can be found through either initial menu choice.

Browsing for Measures

To compare several related measures, rather than simply accepting the measure(s) identified by the selection menus, browsing the measure summaries may be the best option.

Begin with the Index of Performance Measure Categories, located on page 333. This index lists the primary categories of performance measures used in this Guidebook, along with the families of performance measures assigned to each category. The eight primary categories are

1. *Availability*, including spatial, temporal, paratransit, and capacity availability;
2. *Service monitoring*, including reliability, customer service, passenger load measures, and goal accomplishment;

3. *Community* measures, covering mobility, outcomes, and the environment;
4. *Travel time* measures, dealing with time and speed;
5. Passenger *safety and security* measures;
6. *Maintenance and construction* measures;
7. *Economic* measures, addressing utilization, efficiency, effectiveness, and administration; and
8. Person and vehicle *capacity* measures.

Secondary categories are *paratransit, comfort, service contracting,* and *ADA accessibility.* Measures included in one of these four categories are also included in one of the primary categories listed above.

The first page of the section assigned to each category describes the types of measures included in that category and, for larger categories, the sub-categories that have been defined for it. The first page also lists related measures in other categories. When using the electronic version of this document, cross-references to other measures are easily accessed by clicking on the provided hyperlinks.

To browse for a measure, select a sub-category that matches the agency's general interest. The performance measures are organized by these sub-categories; look for the measure summaries whose "focus" label matches the sub-category selected. The information provided with each measure's summary will describe the system sizes, modes, and audiences the measure is suited for; and it will describe the kinds of data required to calculate the measure. The measure assessment will describe potential usefulness.

SEARCHING FOR INDIVIDUAL MEASURES

If there is already an individual measure in mind, its summary can be found by using the Index of Performance Measures, which starts on page 338. All of the measures described in this Guidebook are listed in alphabetical order, along with the page number where they are found. Because many measures have been grouped into related "families of measures," and specific measure names may not appear in summary titles, this index is the easiest way to find specific measures.

Measures within a family will be listed under "Examples" in a performance measure summary. Other related measures can be found in the summaries near the original measure's summary; these related measures can be found by looking for measures that have the same "focus" as the measure originally selected. Looking for these related measures may be useful if the assessment of the measure originally selected identifies potential issues with it.

PERFORMANCE MEASURE SELECTION MENUS

Start with Menu 1. Depending on the answer to the question "How would you like to look for a measure," proceed to Menu 2 to find a measure relating to a goal or objective, or proceed to Menu 3 to find measures appropriate for specific system sizes. When the selected menu is located on a different page, use the hyperlinks or the page references to find the next menu. Different types of shading in the menu title (colors in the electronic version) are used to indicate different levels within the menu system. At each new menu, repeat the process of answering a more specific question and moving to the next menu until a summary of an appropriate performance measure is reached. Detailed instructions for using the menus can be found starting on page 154.

Menu 1	**START HERE**	**How would you like to look for a measure?**
By goal or objective	Menu 2	Page 157
By system size	Menu 3	Page 157

Menu 2	**GOALS**	**What does your goal or objective relate to?**
Service availability	Menu 4	Page 158
Service monitoring or delivery	Menu 12	Page 161
Community impact of transit	Menu 17	Page 163
Travel time or speed	Menu 21	Page 164
Safety or security	Menu 24	Page 165
Maintenance or construction	Menu 27	Page 166
Economic and ridership	Menu 29	Page 167
Capacity	Menu 34	Page 168
Service contracting	Menu 35	Page 169
ADA accessibility	Menu 8	Page 159
Non-ADA paratransit service	Menu 36	Page 170
Passenger comfort	Menu 16	Page 162

Menu 3	**POPULATION**	**Select a service type and area population.**
Peer review for any population	Menu 37	Page 170
ADA service, any population	Menu 8	Page 159
General demand-responsive, any population	Menu 36	Page 170
Fixed-route, 1 million or more	Menu 38	Page 171
Fixed-route, 200,000 – 1 million	Menu 42	Page 173
Fixed-route, 50,000 – 200,000	Menu 46	Page 175
Fixed-route, less than 50,000	Menu 50	Page 176

Menu 4	GOAL: SERVICE AVAILABILITY	Pick a category:
Where transit service is provided	Menu 5	Page 158
When transit service is provided	Menu 6	Page 158
Where and when transit service is provided	Menu 7	Page 159
ADA accessibility or paratransit availability	Menu 8	Page 159
Access to information	Menu 9	Page 160
Welfare-to-work access	Welfare-to-Work accessibility	Page 243
Service equity	Service equity Local Index of Transit Availability	Page 244 Page 199
Amount of service provided	Menu 10	Page 160
Capacity constraints on availability	Menu 11	Page 160

Menu 5	GOAL: SPATIAL AVAILABILITY	I want to know...
As much as possible with limited data	Route (corridor) spacing Route coverage Service density	Page 179 Page 181 Page 182
How much area is served by transit	Service coverage	Page 180
How many people or jobs are served by transit	Accessibility Welfare-to-Work accessibility	Page 241 Page 243
How easy it is to walk, bike, or drive to a transit stop	Stop spacing Stop accessibility	Page 183 Page 184
Where potential demand for service exists	Transit Orientation Index	Page 185

Menu 6	GOAL: TEMPORAL AVAILABILITY	I want to know...
How often service is provided on a particular route	Frequency	Page 186
How long service is provided on a particular route during the day	Hours (Span) of service	Page 187
How many miles vehicles travel	Vehicle coverage	Page 188
How many hours vehicles are in service	Service hours	Page 189
How many hours vehicles are carrying passengers	Revenue hours	Page 190
The likelihood that a particular user will be able to board the next vehicle that arrives	Fleet composition Passenger load	Page 192 Page 230
How long it takes for demand-responsive service to pick up a passenger once a service request is made	Response (Access) time	Page 191
How often demand-responsive passengers fail to show up for a trip	Number of late cancellations and no-shows	Page 322
How easy it is for passengers to remember the schedule	Percent of routes scheduled to clock headways	Page 193
If the service in one area is comparable to the service in another area	Service equity Local Index of Transit Availability	Page 244 Page 199

Menu 7	GOAL: SPATIAL AND TEMPORAL AVAILABILITY	I want to know...
As much as possible with limited data	Menu 5 Menu 6	Page 158 Page 158
How service in this city compares to another	Index of Transit Service Availability	Page 200
Relative amounts of service within different parts of a metropolitan area	Local Index of Transit Availability	Page 199
How convenient it is to travel between specific origins and destinations	Transit Accessibility Index	Page 198
In detail how much service is provided at the stop, route, or system level	Percent person-minutes served	Page 194
How many trip ends have access to transit service during the day	Transit Service Accessibility Index	Page 196
How easily passengers can purchase passes and discount tickets	Number of fare media sales outlets	Page 201

Menu 8	GOAL: ADA ACCESSIBILITY	I want to know...
Where service must be or is provided	Route (Corridor) spacing Service coverage	Page 179 Page 180
How long service is provided during the day	Hours (Span) of service	Page 187
How easily customers can access the fixed-route system	Stop accessibility Fleet composition	Page 184 Page 192
How many hours vehicles are in service	Service hours	Page 189
How many hours vehicles are carrying passengers	Revenue hours	Page 190
How often customers are not provided service at or near the time they request	Service denials	Page 202
How often customers are picked up at the scheduled time	On-time performance (demand-responsive)	Page 208
How often required equipment (e.g., elevators or wheelchair lifts) is in working order	Equipment reliability	Page 215
How convenient it is to make a reservation	Percentage of missed phone calls Percentage of calls held excessively long	Page 219 Page 220
How often passengers fail to show up for a trip	Number of late cancellations and no-shows	Page 322
How easily passengers can get to their destinations	Accessibility Mobility	Page 241 Page 236

Menu 9	GOAL: INFORMATION AVAILABILITY	I want to know…
How easily customers can obtain information	Communications Number of fare media sales outlets	Page 251 Page 201
How easily customers can call into the telephone information center	Percentage of missed phone calls Percentage of calls held excessively long	Page 219 Page 220
How information services compare to other agencies'	Feature existence	Page 232
How well information is provided to passengers during trips	Passenger environment (bus) Passenger environment (rail) Feature existence	Page 225 Page 223 Page 232

Menu 10	GOAL: INFORMATION AVAILABILITY	I want to know…
Compare system resources to population	Population served per vehicles in maximum service	Page 309
Compare system resources to service area	Service area per vehicles in maximum service	Page 310
Compare relative amounts of service within different parts of a metropolitan area	Local Index of Transit Availability	Page 199
Know how much service is provided at the stop, route, or system level	Percent person-minutes served	Page 194
Know how many trip ends have access to transit service during the day	Transit Service Accessibility Index	Page 196

Menu 11	GOAL: CAPACITY AVAILABILITY	I want to know…
As much as possible with limited data	Seat capacity	Page 204
How often passengers are unable to board a transit vehicle due to crowding	Pass-ups Passenger load	Page 203 Page 230
If park-and-ride lots are full	Stop accessibility	Page 184

Menu 12	GOAL: SERVICE DELIVERY	Pick a category:
How well service is provided as scheduled	Menu 13	Page 161
How reliable vehicles are	Menu 14	Page 161
How reliable non-vehicle equipment is	Equipment reliability	Page 215
The quality of customer contacts with agency staff	Menu 15	Page 162
Passenger comfort while using transit	Menu 16	Page 162
How well short-term goals are being accomplished	Action achieved Percent of goal achieved	Page 233 Page 234
The amount of service provided	Service hours Revenue hours	Page 189 Page 190
The ability of passengers to travel at their desired time	Response (access) time Service denials Pass-ups Hours (Span) of service Frequency	Page 191 Page 202 Page 203 Page 187 Page 186
Customer satisfaction with the service provided	Customer satisfaction Ridership	Page 227 Page 301
How likely passengers are to continue using transit or recommend transit to others	Customer loyalty	Page 229

Menu 13	GOAL: SERVICE RELIABILITY	I want to know…
How many trips are made on time by fixed-route service	On-time performance (fixed-route) Run-time ratio	Page 206 Page 217
How many pick-ups or drop-offs are made on-time by demand-responsive service	On-time performance (demand-responsive)	Page 208
How closely scheduled headways match actual headways	Headway regularity	Page 209
How often trips are removed from the schedule	Missed trips Lost service Percentage of scheduled vehicles placed into service	Page 211 Page 212 Page 213

Menu 14	GOAL: VEHICLE RELIABILITY	I want to know…
How often vehicles break down	Road calls	Page 289
The impact of vehicle breakdowns	Missed trips Lost service Percentage of scheduled vehicles placed into service	Page 211 Page 212 Page 213
How well incidents are managed	Scheduled miles per minute of delay	Page 214
How old the fleet is	Mean vehicle age	Page 216

Menu 15	**GOAL: CUSTOMER INTERACTION**	**I want to know…**
As much as possible with limited data	Complaint (Compliment) rate	Page 218
How many callers hang up before reaching an agency representative	Percentage of missed phone calls	Page 219
How many callers wait on hold longer than desired	Percentage of calls held excessively long	Page 220
How long it takes to respond to customer questions or complaints	Customer response time	Page 221
The quality of customer interactions with agency staff	Driver courtesy Passenger environment (bus) Passenger environment (rail)	Page 222 Page 225 Page 223

Menu 16	**GOAL: PASSENGER COMFORT**	**I want to know…**
Comprehensive information about passenger comfort while using transit	Passenger environment (bus) Passenger environment (rail) Customer satisfaction	Page 225 Page 223 Page 227
Passenger comfort at bus stops	Percentage of stops with shelters and benches	Page 226
Passenger comfort on board transit vehicles	Passenger load Percent of vehicles with functioning climate control systems Equipment reliability Mean vehicle age Feature existence	Page 230 Page 297 Page 215 Page 216 Page 232
How clean transit vehicles are	Fleet cleaning Passenger environment (bus) Passenger environment (rail)	Page 292 Page 225 Page 223
How much noise passengers experience while using transit	Noise impact	Page 257
How much time passengers spend during different portions of their transit trips	Travel time Transfer time Frequency Headway regularity	Page 260 Page 268 Page 186 Page 209

Menu 17	GOAL: COMMUNITY IMPACT	Pick a category:
How easily destinations can be reached by transit	Menu 18	Page 163
Ways that transit affects a community	Menu 19	Page 163
The impact of transit on the environment	Menu 20	Page 164

Menu 18	GOAL: MOBILITY	I want to know...
The ease of travel between origins and destinations	Mobility Accessibility Welfare-to-work accessibility	Page 236 Page 241 Page 243
How transit affects the number of automobile trips being made	Trip generation	Page 238
The number of people for whom transit could be a significant travel mode	Demographics	Page 240
Differences in transit benefits and impacts on different portions of the community	Service equity Community cohesion	Page 244 Page 246
How much of the community is served	Service coverage Route (Corridor) spacing Service hours	Page 180 Page 179 Page 189
The ability of passengers to travel at their desired time	Response (access) time Service denials Pass-ups Hours (Span) of service Frequency	Page 191 Page 202 Page 203 Page 187 Page 186

Menu 19	GOAL: OUTCOMES	I want to know...
How transit contributes to a community's economic growth	Community economic impact	Page 247
How transit improves an individual's financial well-being	Personal economic impact	Page 249
The financial return on the community's investment in transit	Efficiency	Page 250
How well the agency communicates with its community	Communications	Page 251
How many employable persons use transit to commute to work	Employment impact	Page 252
How transit service and facilities affect nearby property values	Property value impact	Page 253
The amount of new development or redevelopment near transit stations	Land development impact	Page 254

Menu 20	GOAL: ENVIRONMENTAL IMPACT	I want to know…
Transit's effect on energy and resource consumption	Resource consumption impact Energy consumption	Page 255 Page 306
The effects of transit investment and use on the environment	Environmental impact	Page 256
The amount of noise produced by transit facilities	Noise impact	Page 257

Menu 21	GOAL: TRAVEL TIME AND SPEED	Pick a category:
The time required for an individual trip	Travel time	Page 260
The time required for a transit trip, compared to the same trip made by automobile	Transit-auto travel time Transit-auto travel speed ratio	Page 263 Page 274
The day-to-day variability in travel times	Travel time variability Reliability factor	Page 262 Page 264
How much a route deviates from the shortest route between its starting and ending points	Route directness	Page 265
The impact of transfers of overall travel time	Menu 22	Page 164
The amount of delay experienced while making a trip	Menu 23	Page 164
The average speed of transit vehicles	Travel speed System speed	Page 272 Page 273

Menu 22	GOAL: TRANSFERS	I want to know…
The number of transfers required for an individual trip	(Maximum) Number of transfers	Page 266
The number of trips requiring transfers	Percent of trips requiring transfers	Page 267
The amount of time required for a typical transfer	Transfer time	Page 268

Menu 23	GOAL: DELAY	I want to know…
The difference in travel time between optimal conditions and actual conditions	Delay	Page 269
The amount of traffic congestion experienced	Relative delay rate Travel rate index	Page 270 Page 271

Menu 24	**GOAL: SAFETY AND SECURITY**	**Pick a category:**
Vehicle and property damage	Accident rate Number of fires Risk management	Page 276 Page 283 Page 325
Passenger accidents	Passenger safety Risk management	Page 277 Page 325
Accident potential	Menu 25	Page 165
Workplace safety	Employee work days lost to injury Risk management	Page 279 Page 325
Passenger security	Menu 26	Page 165

Menu 25	**GOAL: ACCIDENT POTENTIAL**	**I want to know…**
Drug-related accident potential	Percent of positive drug/alcohol tests	Page 278
Bus operator accident potential	Number of traffic tickets issued to operators Percent of buses exceeding speed limit	Page 280 Page 281
Rail operator accident potential	Number of station overruns	Page 282
Maintenance-related accident potential	Road calls Fleet maintenance performance	Page 289 Page 320

Menu 26	**GOAL: PASSENGER SECURITY**	**I want to know…**
The number of crimes committed on transit property	Number of crimes (Crime rate)	Page 284
The level of security provided	Ratio of transit police officers to transit vehicles Number (Percent) of vehicles with specified safety devices	Page 285 Page 286
Customer perceptions of the safety and security of the transit system	Customer satisfaction Incidents of vandalism	Page 227 Page 287

Menu 27	GOAL: MAINTENANCE AND CONSTRUCTION	Pick a category:
Vehicle breakdowns	Road calls Distance between breakdowns (service interruptions)	Page 289 Page 290
Vehicle reliability	Menu 28	Page 166
Vehicle and facility cleaning	Fleet cleaning Passenger environment (bus) Passenger environment (rail) Customer satisfaction	Page 292 Page 225 Page 223 Page 227
Preventive maintenance	Maintenance program effectiveness Number of defects reported by operators	Page 321 Page 298
Passenger comfort	Percent of vehicles with functioning climate control systems Passenger environment (bus) Passenger environment (rail) Customer satisfaction	Page 297 Page 225 Page 223 Page 227
Ability to respond to vehicle breakdowns	Spare ratio Average spare ratio vs. scheduled spare ratio Lost service	Page 293 Page 294 Page 212
Maintenance program cost	Fleet maintenance performance	Page 320
Maintenance program results	Maintenance program effectiveness	Page 321
Effects of construction on passengers	Customer impact index Customer satisfaction	Page 299 Page 227

Menu 28	GOAL: VEHICLE RELIABILITY	I want to know…
The reliability of a particular bus model	Maintenance work orders per bus model vs. the total fleet	Page 291
The likelihood of a particular vehicle component failing	Average life of major vehicle components Average age of major vehicle components Mean vehicle age	Page 295 Page 296 Page 216
The reliability of a particular vehicle component	Equipment reliability	Page 215

Menu 35	GOAL: SERVICE CONTRACTING	I want to set...
The maximum distance allowed between parallel routes	Route (Corridor) spacing	Page 179
The minimum amount of service provided	Service hours Revenue hours	Page 189 Page 190
The maximum time a passenger must wait to use demand-responsive service	Response (Access) time	Page 191
The maximum number of trips that can be turned down per time period	Service denials	Page 202
A minimum standard for picking up and delivering passengers at the promised times	On-time performance (fixed-route) On-time performance (demand-responsive)	Page 206 Page 208
The maximum number of scheduled trips that are not made	Missed trips	Page 211
The maximum number of complaints received per number of passengers carried	Complaint rate	Page 218
A minimum standard for service quality provided by a telephone reservation center	Percent of missed phone calls Percent of calls held excessively long	Page 219 Page 220
A minimum standard for driver courtesy	Driver courtesy Complaint rate	Page 222 Page 218
A minimum standard of customer satisfaction with the contracted service	Customer satisfaction	Page 227
A minimum or maximum speed used for scheduling demand-responsive service	System speed	Page 273
A maximum number of preventable accidents	Accident rate	Page 276
A maximum number of vehicle breakdowns	Road calls Distance between breakdowns (service interruptions)	Page 289 Page 290
A minimum interval between vehicle interior and exterior cleanings	Fleet cleaning	Page 292
A maximum amount of deadhead running	Service miles per revenue mile	Page 308
A maximum cost per passenger	Cost effectiveness	Page 312
A minimum number of passengers carried per hour	Productivity	Page 314

Menu 36	GOAL: GENERAL DEMAND-RESPONSIVE SERVICE	I want to know…
Areas where demand-responsive service might be appropriate	Demographics	Page 240
Areas that might be suitable for substituting fixed-route service for demand-responsive	Service coverage	Page 180
How many hours vehicles are in service	Service hours	Page 189
How many hours vehicles carry passengers	Revenue hours	Page 190
How often customers are not provided service at or near the time they request	Service denials	Page 202
How long it takes for service to be provided once a service request is made	Response (Access) time	Page 191
How often demand-responsive passengers fail to show up for a trip	Number of late cancellations and no-shows	Page 322
How many pick-ups or drop-offs are made on time by our demand-responsive service	On-time performance (demand-responsive)	Page 208
How often trips are removed from the schedule	Missed trips Lost service Percentage of scheduled vehicles placed into service	Page 211 Page 212 Page 213
How many callers hang up before reaching a reservations operator	Percentage of missed phone calls	Page 219
How many callers wait on hold longer than desired for a reservations operator	Percentage of calls held excessively long	Page 220
The average speed transit vehicles travel at	Travel speed System speed	Page 272 Page 273

Menu 37	ALL SYSTEM SIZES: PEER REVIEW	I want to compare…
Service availability	Route coverage Vehicle coverage	Page 181 Page 188
Service delivery	Missed trips Mean vehicle age Feature existence	Page 211 Page 216 Page 232
Fares	Personal economic impact	Page 249
Transit's community impact	Personal economic impact	Page 249
Effect of congestion on transit operations	Travel speed	Page 272
Safety	Accident rate	Page 276
Vehicle maintenance	Road calls	Page 289
Vehicles available as substitutes	Spare ratio	Page 293
Number of passengers carried	Ridership	Page 301
Cost of providing service	Cost effectiveness	Page 312
Service provided during peak periods	Peak-to-base ratio	Page 311

NOTE: This menu only lists measures that are readily available and likely to be measured consistently between systems. Depending on what the peer review is intended to compare, other measures may also need to be considered, but should be examined carefully to make sure that data are reported consistently between systems.

Menu 38	POPULATION OVER 1 MILLION	Pick a category:
Service provision	Menu 39	Page 171
Transit's impact on the community	Menu 40	Page 172
Agency operation	Menu 41	Page 172

Menu 39	LARGE SYSTEM: PASSENGER MEASURES	I want to know...
Where service is provided	Service coverage	Page 180
When service is provided	Frequency Hours (Span) of service	Page 186 Page 187
Where and when service is provided	Percent person-minutes served	Page 194
ADA and pedestrian accessibility of bus stops	Stop accessibility	Page 184
Park-and-ride lot space availability	Stop accessibility	Page 184
How reliable service is	On-time performance (fixed-route) Missed trips Headway regularity	Page 206 Page 211 Page 209
How easily passengers can purchase passes	Number of fare media sales outlets	Page 201
What passengers experience while using transit	Passenger environment (bus) Passenger environment (rail) Complaint (Compliment) rate	Page 225 Page 223 Page 218
Customer satisfaction and loyalty	Customer satisfaction Customer loyalty	Page 227 Page 229
How long it takes to respond to customers	Customer service response time	Page 221
Which trips are the most crowded	Passenger load	Page 230
The variability of travel times on a route	Reliability factor	Page 264
How direct route alignments are	Route directness	Page 265
Impacts of transfers	Percent of trips requiring transfers Transfer time	Page 267 Page 268
The effect of traffic on transit service	Travel speed	Page 272
How much longer it takes to travel by transit	Transit-auto travel time	Page 263
How safely service is provided	Accident rate Passenger safety	Page 276 Page 277
How secure passengers are while using transit	Number of crimes (Crime rate) Number (Percent) of vehicles with specified safety devices Ratio of transit police officers to transit vehicles	Page 284 Page 286 Page 285

Menu 42	POPULATION BETWEEN 200,000 AND 1 MILLION	Pick a category:
Service provision	Menu 43	Page 173
Transit's impact on the community	Menu 44	Page 174
Agency operation	Menu 45	Page 174

Menu 43	MEDIUM SYSTEM: PASSENGER MEASURES	I want to know…
Where service is provided	Service coverage	Page 180
When service is provided	Frequency Hours (Span) of service	Page 186 Page 187
Where and when service is provided	Percent person-minutes served	Page 194
ADA and pedestrian accessibility of bus stops	Stop accessibility	Page 184
How reliable service is	On-time performance (fixed-route) Missed trips	Page 206 Page 211
How easily passengers can purchase passes	Number of fare media sales outlets	Page 201
Customers' perceptions of service quality	Complaint (Compliment) rate Customer satisfaction	Page 218 Page 227
How long it takes to respond to customers	Customer service response time	Page 221
Which trips are the most crowded	Passenger load	Page 230
The variability of travel times on a route	Reliability factor	Page 264
How direct route alignments are	Route directness	Page 265
Impacts of transfers	Percent of trips requiring transfers Transfer time	Page 267 Page 268
The effect of traffic on transit service	Travel speed	Page 272
How much longer it takes to travel by transit	Transit-auto travel time	Page 263
How safely service is provided	Accident rate Passenger safety	Page 276 Page 277
How secure passengers are while using transit	Number of crimes (Crime rate) Number (Percent) of vehicles with specified safety devices Ratio of transit police officers to transit vehicles	Page 284 Page 286 Page 285

Menu 44	MEDIUM SYSTEM: COMMUNITY MEASURES	I want to know...
How easily persons can travel by transit	Mobility	Page 236
Which areas are potentially underserved	Demographics	Page 240
The distribution of transit impacts and benefits	Service equity	Page 244
Transit's contribution to economic growth	Community economic impact	Page 247
Transit's impact on passenger finances	Personal economic impact	Page 249
Transit's impact on local employment	Employment impact	Page 252
Transit's impact on the environment	Environmental impact	Page 256

Menu 45	MEDIUM SYSTEM: AGENCY MEASURES	I want to know...
How well the agency provides information to the public	Communications	Page 251
How safe the workplace is	Employee work days lost to injury	Page 279
If there are potential driver safety issues	Percent of positive drug/alcohol tests	Page 278
The extent of any vandalism problems	Number of incidents of vandalism	Page 287
The quality of maintenance	Road calls	Page 289
The quality of vehicles	Maintenance work orders per bus model vs. the total fleet	Page 291
The lifespan of vehicle components	Average life of major vehicle components Average age of major vehicle components Mean vehicle age	Page 295 Page 296 Page 216
Vehicle cleanliness	Fleet cleaning	Page 292
How often spare vehicles are not available	Average spare ratio vs. scheduled spare ratio	Page 294
Number of passengers carried	Ridership Productivity	Page 301 Page 314
Vehicle fuel economy	Energy consumption	Page 306
Cost of providing service	Cost efficiency Cost effectiveness	Page 307 Page 312
Overall management performance	Administrative performance	Page 319
How well the maintenance department performs	Maintenance program effectiveness Fleet maintenance performance	Page 321 Page 320
Employee satisfaction and productivity	Employee productivity Employee relations	Page 323 Page 324
How much special event service is needed	Person capacity	Page 327
The capacity of major transit streets	Vehicle capacity	Page 331

Menu 46	POPULATION BETWEEN 50,000 AND 200,000	Pick a category:
Service provision	Menu 47	Page 175
Transit's impact on the community	Menu 48	Page 175
Agency operation	Menu 49	Page 176

Menu 47	SMALL SYSTEM: PASSENGER MEASURES	I want to know…
Where service is provided	Route coverage	Page 181
When service is provided	Frequency Hours (Span) of service	Page 186 Page 187
ADA accessibility of bus stops	Stop accessibility	Page 184
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AVAILABILITY MEASURES

Availability measures assess how easily potential passengers can use transit services for various kinds of trips. If transit service is not available to a passenger for a particular trip, other aspects of transit service will not matter to that passenger, as the trip will be made by some other mode or not made at all. This section divides availability into four main sub-categories:

1. *Spatial availability*—where is service provided and can one get to it;
2. *Temporal availability*—how often and how long is service provided;
3. *Paratransit availability*—measures unique to paratransit; and
4. *Capacity availability*—service is provided, but no room exists for additional passengers to use it.

Information availability (can one find out how to use transit) can be measured by a *passenger environment* survey (a service monitoring measure) or by *communications* (a community measure). Measures specifically relating to various aspects of ADA accessibility are listed in the index of performance measure categories.

The following measures discussed in other sections of this performance measure summary also have some relationship to transit availability:

- Equipment reliability,
- Percent of missed phone calls,
- Percent of calls held excessively long,
- Mobility,
- Accessibility,
- Welfare-to-work accessibility,
- Service equity,
- Population served per vehicles in maximum service,
- Service area per vehicles in maximum service, and
- Number of late cancellations and no-shows.

◆ Route (Corridor) Spacing

Distance between two parallel routes or corridors

Focus: spatial availability

Other Uses: paratransit, service contracting, ADA accessibility, community

Modes: bus and rail

Scope: route

System Size: any

Audience: service planners

Description: Measures such as *route spacing* and *corridor spacing* indicate how well the service area is covered by transit routes and how well the transit agency distributes its resources. *Service to as many residences as possible* and *service to as many non-residential trip generators as possible* are goals that relate to these measures of service coverage.

Example target values: One-half mile spacing is typically required in high-density areas. One-mile spacing is typically used for express routes.

Major factors: Connectivity of desired origins and destinations, route structure (e.g., radial express), population density, employment density, relation of spacing standards to access (e.g., walking distances and transfer distances), frequency and span of service, location of stops and stations, walk distances versus air distances

Data requirements: Distances between routes/stops (existing and/or proposed)

Assessment: This measure is a simple indicator of service coverage. It should be only used as a starting point for designing or evaluating service coverage, as there are many other factors that influence whether or not coverage is "good."

❖ Service Coverage

Area served by transit

Focus:	spatial availability
Other Uses:	community, paratransit
Examples:	area served by transit, percent transit-supportive area served by transit
Modes:	all
Scope:	system
System Size:	any
Audience:	public, decision-makers, service planners

Description: Service coverage measures assess how much area has access to transit service and can be calculated as either a number or a percentage. The area served by a stop or route must be defined to determine the extent of the transit service area. The TCQSM uses *percent transit-supportive area served* as its measure and uses ¼-mile air distances from bus stops and ½-mile air distances from rail and bus rapid transit stations as its service area. A "transit-supportive area" is defined as an area capable of supporting hourly transit service (minimum household density of 3 households per gross acre, or minimum job density of 4 jobs per gross acre). Service coverage can also be measured in terms of the number of people and/or jobs served by transit; this application is described under *accessibility* in the community measures section. For demand-responsive service, the entire service area should be included; the ADA requires a minimum of ¾ mile from fixed-route service for complementary ADA service.

Example target values: Communities interested in maximizing access to transit often specify a percentage (e.g., 90%) of households that should be within walking distance of transit. The TCQSM First Edition uses the following LOS thresholds for *percent transit-supportive area served*: "A" = 90-100%, "B" = 80-89%, "C" = 70-79%, "D" = 60-69%, "E" = 50-59%, "F" = <50%.

Major factors: Route and stop spacing, population and job density, demographics (for community goals), walking distances, street and pathway connectivity, pedestrian walking environment

Data requirements: Data requirements vary greatly depending on the level of detail desired. While these measures in theory could be calculated using pen and paper for a small area (a neighborhood or small city, for example), the use of GIS software is highly recommended. At a minimum, information on transit route locations is needed to calculate area-based measures (assuming a minimum stop spacing of ¼ mile), with transit stop locations preferable (and essential for rail lines and busways). Accounting for actual walking paths to transit stops (as opposed to using air distances) requires advanced GIS software and information on pedestrian pathway locations and possibly the pedestrian walking environment. The TCRP A-15A project is developing factors for the TCQSM Second Edition that adjust maximum walking distances based on street network patterns, grades, street crossing delay, and population type.

Assessment: Service coverage measures can be very useful for identifying gaps in service and for determining the areas where transit is a mode choice option. However, these measures should be used in combination with temporal availability measures to get a complete picture of transit service. The amount of detail involved in developing a stop's service coverage area is an important factor in how accurate the final answer will be. For rural areas, *percent population or jobs served* types of measures (see *accessibility*) are preferable to density- or area-based measures. Increasing service coverage can decrease other performance measures such as *travel time* (if routes are deviated more to obtain more coverage) or *cost-effectiveness* (if service is added to areas with poor ridership potential).

Reference: TCQSM (***2***)

❖ Route Coverage

Planning-level spatial availability measures

Focus: spatial availability

Examples: route miles per square mile, route miles per capita, directional route miles per square mile, transit street miles per square mile

Modes: fixed-route

Scope: sub-area, system

System Size: any

Audience: service planners, MPOs/transportation planners

Description: Service coverage measures tend to require a moderate to considerable degree of effort to calculate. Route coverage measures use data that are generally already on hand and thus are easier to calculate, but generally provide more macroscopic results.

Example target values: Washington, D.C., provided 4.3 directional route-miles per square mile in 1990. Its peer group (i.e., cities with a population density greater than 2,000 and a population greater than 1 million) provided an average of 3.3 directional route-miles per square mile in 1990.

Major factors: Route locations, street network design (e.g., grid vs. curvilinear)

Data requirements: Distance traveled by each route within the study area

Assessment: The usefulness of these measures depends on how well transit routes are spread out within the study area. Five routes operating on the same street and five parallel routes spaced 1/4 mile apart will produce the same result, even though the amount of coverage is considerably different. Measuring *transit street miles per square mile* produces better results than, say, *route miles per square mile*, but can still be affected by, for example, one-way street systems and one-way routes vs. two-directional routes. Areas where the streets run in a grid may have lower results than areas where streets wind around, even though the number of locations with access to transit may be similar. *Route miles per square mile* is one of three components of the *Local Index of Transit Availability*. Related families of measures are *vehicle coverage* and *seat capacity*.

◆ Service Density

The number of routes in a zone

Focus:	spatial availability
Modes:	all
Scope:	zone
System Size:	any
Audience:	service planners, MPOs/transportation planners

Description: This measure is the number of routes within walking distance of a zone.

Example target values: Petersen (***37***) used a maximum of 10 routes passing through a zone in his Chicago correlation analysis.

Major factors: Size of zone, air distance vs. walking distance, number of stops, stop locations, walking environment, population and employment density and distribution within zones, service span, headway

Data requirements: Advanced GIS software for walking distance buffers, zone structure, route alignment

Assessment: This measure is intended to approximate connectivity, assuming that "more options in terms of routes means one is more likely to have access to more destinations." The measure does this very roughly. The measure can be matched with census data for comparing zones' transit service equity, but the measure will not assess how well transit service is utilized, its frequency, or its service span.

◆ Stop Spacing

Average distance between transit stops

Focus: spatial availability

Modes: fixed-route bus with designated stop locations, rail

Scope: route

System Size: any

Audience: public, service planners

Description: Stop spacing is often used as a design standard when developing new routes or consolidating stops on existing routes. The standard chosen represents a trade-off between two competing goals: maximizing access to transit and maximizing travel time after boarding a transit vehicle.

Example target values: Six to eight stops per mile was the most common spacing standard for local bus services identified in a 1995 survey of 111 agencies. Longer stop spacings are appropriate for limited-stop and express services. Average rail station spacings reported in the TCQSM for U.S. and Canadian systems are automated guideway transit—0.43 miles, light rail—0.52 miles, heavy rail—0.91 miles, and commuter rail—3.55 miles.

Major factors: Locations of access points from the surrounding area to streets with transit service, locations of transit trip generators and transfer points, travel time and/or system speed requirements, availability of locations to place transit stops

Data requirements: Route length and number of stops

Assessment: Stop spacing is a common measure used in designing service, but it is less useful in an ongoing (e.g., monthly) performance monitoring program, as stop locations will change infrequently. The TCQSM (***2***) provides methods of estimating changes in transit vehicle travel speeds that would result from changes in stop spacing.

❖ Stop Accessibility

Measures of how easily one can walk, bike, or drive to a transit stop

Focus: spatial availability

Examples: pedestrian level of service, bicycle level of service, percent of stops/stations ADA accessible, percent of park-and-ride-lot spaces filled, street crossing difficulty, number of bicycle rack spaces/bicycle lockers, network connectivity index

Modes: all

Scope: stop, route

System Size: any

Audience: public, decision-makers, facility planners, public works departments

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Description: Most transit passengers must use another transportation mode (e.g., walking, biking, driving) at one or both ends of their trip. Transit service is more competitive with the automobile if one can safely and easily get from one's origin and destination to the transit stop. Stop accessibility measures assess the quality of the walking, biking, and/or driving environment in the vicinity of transit stops, or along transit routes. These measures also assess whether there is space to park one's car or store one's bicycle once one arrives at a stop.

The *network connectivity index* is a measure of how easily pedestrians can access a transit stop from locations in the stop's vicinity. It is the number of links (i.e., street segments between intersections), divided by the number of nodes (i.e., intersections) in a roadway system. The index value ranges from about 1.7 for a well-connected grid pattern to approximately 1.2 for a cul-de-sac network. In a contemporary (cul-de-sac–based) land use pattern, about 55% fewer destinations within ¼-mile air distance of the stop are within ¼-mile walking distance of the stop, compared to a grid pattern.

Example target values: Oshkosh Transit's goal is 100% stops ADA accessible. MUNI's goal is to meet or exceed ADA accessibility standards by 2002.

Major factors: Sidewalk presence, sidewalk condition, sidewalk width, terrain, street widths, amount and type of separation between traffic lanes and pedestrian or bicycle facilities, traffic volumes, presence of curb cuts, park-and-ride demand, number of park-and-ride spaces provided, number of bicycle racks and lockers provided, type of traffic control provided at intersections, land development patterns.

Data requirements: Pedestrian and bicycle environment measures typically require information on traffic volumes, pedestrian/bicycle facility type and width, and the degree of separation between the facility and general traffic. This information may be available from the local roadway agency or may require a windshield survey. ADA accessibility measures generally require a more detailed evaluation of conditions at and near a given stop (e.g., grades, lateral clearances, surface hardness, etc.). Park-and-ride utilization requires knowledge of the number of spaces provided at a lot and parking counts. The *network connectivity index* requires information on the number of streets and intersections within an area.

Assessment: Access to transit has received greater attention in recent years by researchers, as it is believed to influence ridership. Many of the factors that influence stop accessibility are not under the direct control of transit agencies (e.g., presence of sidewalks or bicycle lanes) or, in some cases, any agency (traffic volumes). These measures generally involve some level of field data collection.

References: Guttenplan, et al. (pedestrian and bicycle LOS) (***38***); Harkey (bicycle LOS) (***39***); FDOT Public Transit Office (street crossing difficulty) (***40***); Ewing (network connectivity index) (***41***), TCQSM (***2***) (network connectivity)

◆ Transit Orientation Index

Planning-level measure for determining how much transit service should be provided

Focus: spatial availability

Modes: fixed-route

Scope: route, system

System Size: medium, large

Audience: service planners, policy makers, MPOs/transportation planners

Description: The Transit Orientation Index (TOI) is a scored estimate of ridership in a TAZ that is based on a locally developed regression model that relates ridership to employment, housing, and retail employment densities. It is an availability measure in the sense that it evaluates whether and how much transit service should be available to a TAZ. The higher the TOI, the greater the potential demand for transit in a zone.

Major factors: Level of population and employment data aggregation, population and employment density

Data requirements: Employment density, housing density, and retail employment density by TAZ

Assessment: The ridership estimation model and resulting index were developed and calibrated only for Portland, Oregon; but the methodology could be used elsewhere. The measure is intended to be used for planning rather than operational analysis. This measure, unlike other availability measures, relates the amount of service provided to the amount that is needed. It is very broad, though, as it does not recommend a *specific* amount of service; it compares different TAZs only to prioritize them.

Reference: Nelson\Nygaard (***42***)

❖ Frequency

The number of transit vehicles per hour or day

Focus: temporal availability

Examples: frequency, headway, policy headway

Modes: all

Scope: stop, route, origin-destination pair

System Size: any

Audience: public, decision-makers, service planners

Description: Frequency measures how often transit service is provided, either at a location or between two locations. The most commonly used measures are *frequency* (transit vehicles per hour) and its reciprocal, *headway* (time interval between transit vehicles). Services that operate infrequently may be better measured in trips per day; some rural services may be measured in trips per week or month. *Policy headways* are used in service planning to relate the minimum headway provided to other factors, such as passenger volumes or land use patterns at the route terminals or along the route.

Example target values: The TCQSM First Edition (***2***) defines the following LOS ranges for headway for urban fixed-route service: "A" = <10 minutes, "B" = 10-14 minutes, "C" = 15-20 minutes, "D" =21-30 minutes, "E" = 31-60 minutes, "F" = >60 minutes. For intercity service, the ranges are: "A" = >15 trips/day, "B" = 12-15 trips/day, "C" = 8-11 trips/day, "D" = 4-7 trips/day, "E" = 2-3 trips/day, "F" = 0-1 trips/day. The maximum allowable policy headway might range from 30 minutes to two hours; the minimum allowable headway might be two minutes (to try to avoid bus bunching or due to rail signaling constraints). The Chicago Transit Authority relates policy headways related to passenger volumes: at low frequencies (long headways), all passengers should have a seat, while at high frequencies (short headways), some level of standees would be permitted. TriMet's long-range service plan relates policy headways to estimated ridership based on future land use patterns.

Major factors: Passenger demand, loading standards, liability issues (need to avoid standees), time of day, direction, policies requiring service provision in certain areas

Data requirements: Scheduled headways

Assessment: Frequency is an excellent measure of how often service is provided. When used, measures of how long and where service is provided should also be used to obtain a more complete picture of service availability. Frequency reflects the amount of service scheduled; not necessarily the amount of service provided.

Comments: The TCQSM Second Edition is expected to drop the intercity frequency measure.

◆ Hours (Span) of Service

How long service is provided during a day

Focus: temporal availability

Modes: all

Scope: stop, route, origin-destination pair

System Size: any

Audience: public, decision-makers, service planners

Description: Hours of service is the number of hours during a day that transit service is provided. Hours of service can vary by day of the week, by route, and even by stop. The length of the service day impacts the convenience of transit for passengers and can constrain the types of trips that can be made by transit.

Example target values: Express routes may provide only weekday peak-hour service (4-6 hours of service). The TCQSM First Edition (***2***) uses the following level-of-service thresholds: “A” = 19-24 hours/day, “B” = 17-18 hours/day, “C” = 14-16 hours/day, “D” = 12-13 hours/day, “E” = 4-11 hours/day, “F” = 0-3 hours/day; these thresholds are best suited for evaluating overall service at a stop or between origin-destination pairs, rather than individual routes (different route numbers may be used at night, or local service may be available when express routes do not run). LOS thresholds are expected to be the same in the TCQSM Second Edition.

Major factors: Ridership, hours of operation at desired origins and destinations, maintenance needs (for vehicles, guideways, stops, and stations)

Data requirements: Hours of operation

Assessment: Hours of service is a measure of supply and does not reflect utilization. *TCRP Report 54* (***43***) recommends that this measure “…should be used to track convenience, but with caution…” for small and rural transit systems. When used for urban systems, measures of how often and where service is provided should also be evaluated, to obtain a more complete picture of transit availability.

Comments: The TCQSM Second Edition is expected to introduce a new service span LOS measure for demand-responsive transit that is based on a combination of the number of days of service per week and the hours of service on days service is provided. The LOS scale is expected to be numerical (e.g., 1-8) rather than alphabetical (e.g., A-F).

❖ Vehicle Coverage

Planning-level temporal availability measures

Focus: temporal availability

Examples: vehicle miles/hours per square mile, vehicle miles/hours per capita, vehicle miles/hours per route mile, vehicles per zone per hour, annual vehicle miles traveled

Modes: fixed-route

Scope: sub-area, system

System Size: any

Audience: service planners, MPOs/transportation planners

Description: *Vehicle miles* is the number of miles that transit vehicles travel on their routes in revenue service, including deadheading. It can be divided by the service area population, service area size, and/or route miles to get a planning-level estimate of the amount of service provided. It can also be reported alone, as in *annual vehicles miles traveled*. *Vehicle miles per directional route mile* is a component of the *Index of Transit Service Availability*.

Example target values: Washington, D.C., provided 22,000 vehicle miles per directional route-mile in 1990. Its peer group (i.e., cities with a population density greater than 2,000 and a population greater than 1 million) provided an average of 16,315 vehicle miles per directional route-mile.

Major factors: frequency, population

Data requirements: The data required for these measures are already collected for National Transit Database reporting.

Assessment: These measures provide a generalized indication of the amount of service provided for an area as a whole and use readily available data. They can be used for broad planning purposes and for comparisons of service equity between sub-areas. As with their related families of measures, *route coverage* and *seat capacity*, these measures' usefulness for more detailed planning depends on how similar the service frequency is between routes.

◆ Service Hours

Revenue hours plus deadhead time

Focus: temporal availability

Other Uses: service monitoring, service contracting, community, paratransit

Modes: all

Scope: system

System Size: any

Audience: public, decision-makers, transit management

Description: The number of hours that transit vehicles are in service, including revenue hours (transporting passengers) and deadhead hours (layovers and traveling in revenue service without passengers).

Major factors: Demand and productivity

Data requirements: Driver logs, AVL equipment, or scheduling software

Assessment: Service hours are a prime determinant of the total direct cost of resources expended. It includes the hours that the vehicles are providing service and going to and from revenue service locations. The number of service hours is generally based upon providing sufficient service to meet demand. Lower levels of productivity for demand-responsive service require a higher level of service hours to meet demand.

Service hours are often the baseline for determining productivity (passenger per service hour) and marginal service cost (cost per service hour). Budgeting estimates and costs often depend on the amount of estimated service hours. Many contracts are based on the number of service hours provided. Contractors and agencies providing direct service will base budgeted costs on estimated service hours. All direct costs will be based on the provision of service, including labor, maintenance, insurance, and fuel.

◆ Revenue Hours

The number of transit vehicle hours when passengers are being transported

Focus: temporal availability

Other Uses: service monitoring, service contracting, paratransit

Modes: all

Scope: system

System Size: any

Audience: decision-makers, transit management

Description: Total hours during a specified period when passengers are being transported by revenue vehicles.

Example target values: Houston METRO provided 2,689,896 annual vehicle revenue hours in 1998. The D.C. metropolitan area provided 2,344 total revenue vehicle hours of radial line-haul service on Saturdays in 2000.

Major factors: Transit demand and productivity

Data requirements: Driver logs, AVL equipment, or scheduling software

Assessment: Revenue hours is a measurement used by the NTD and excludes vehicle hours in which revenue is not provided. *Productivity* is often measured by agencies using *passengers per revenue hour* rather than *passengers per service hour*. Given that revenue hours are fewer than service hours, the productivity ratio is higher when revenue hours are used. However, the use of revenue hours masks the time when vehicles are in revenue service but no passengers are being transported.

Revenue hours are also used for budgeting purposes. Improving productivity means that more passengers can be transported in the same number of revenue hours, which is indicative of improved service efficiency.

Reference: NTD (***1***)

◆ Response (Access) Time

Minimum time between when service is requested and when service can be provided

Focus: temporal availability

Other Uses: service monitoring, service contracting, paratransit

Modes: demand-responsive

Scope: system

System Size: any

Audience: public, decision-makers, transit management

Description: Response time is a measure of how much advance planning passengers must do to take a trip on demand-responsive service. It reflects convenience to passengers.

Example target values: The TCQSM's (***2***) level-of-service thresholds for access time are oriented toward the passenger point-of-view (service as soon as possible), rather than the operator's point-of-view (service provided as efficiently as possible, while meeting ADA requirements when applicable): "A" = 0.0-0.5 hours, "B" = 0.6-1.0 hours, "C" = 1.1-2.0 hours, "D" = 2.1-4.0 hours, "E" = 4.1-24 hours, "F" = >24 hours. Most complementary paratransit systems use the minimum ADA requirement of one day's advance notice.

Major factors: Transit demand and productivity, scheduling software sophistication, ADA requirements

Data requirements: Dispatcher logs or scheduling software

Assessment: Response time is best suited for (1) systems that intend to provide same-day service to passengers (to monitor performance) and (2) complementary paratransit services (to monitor compliance with ADA requirements). It measures how soon service was provided, but not whether the times that pick-ups and drop-offs were scheduled actually met passengers' needs or whether service was actually provided at the promised time (e.g., *missed trips*, *on-time performance*).

Comments: The TCQSM Second Edition will likely move to a numerical (e.g., 1-8) scale for demand-responsive LOS measures. The response time measure is expected to be expanded to cover a greater range of demand-responsive service types and access times.

❖ Fleet Composition

Percent of fleet accessible to particular groups of users

Focus: temporal availability

Examples: percent of trips/vehicles that are wheelchair accessible, percent of fleet composed of low-floor buses, percent of bus fleet equipped with bicycle racks

Modes: all

Scope: route, system

System Size: any

Audience: public, decision-makers, transit management

Description: When not all of the vehicles assigned to a transit route are accessible to certain groups of users, the effective frequency of that route for those users is lower, as only the accessible vehicles can be used to travel. *Percent of trips/vehicles that are wheelchair accessible* reflects the general level of mobility offered for persons using wheelchairs; *percent revenue miles wheelchair accessible* is a variation of this measure. *Percent of fleet composed of low-floor buses* addresses ease of access for passengers who have trouble climbing steps to board a vehicle (whether due to age, disability, strollers, etc.). *Percent of bus fleet equipped with bicycle racks* addresses service availability to persons who incorporate a bus trip as part of an overall bicycle trip. These measures can also be used to track progress toward an agency goal of being fully wheelchair accessible, 100% low-floor, or fully bicycle accessible.

Example target values: Houston METRO in 1999 had 1,360 buses. Of these, 68% were accessible.

Major factors: vehicle replacement schedules, ADA requirements

Data requirements: Fleet and model data provide the number of vehicles with particular types of equipment and the total fleet size. Using the percent trips or per revenue mile versions of these measures also requires tracking which vehicles are assigned to which trips.

Assessment: Measuring the number of daily trips by wheelchair-accessible vehicles provides a better indication of transit availability for wheelchair users than the percentage of wheelchair-accessible vehicles, because the non-accessible vehicles may be used as spares or for a limited number of trips per day. These measures reflect the ability of particular groups of users to travel between two stops; they do not indicate if these users can get to and from the transit stops. *Percent of stops ADA accessible* provides a measure of spatial availability for customers using wheelchairs and for other persons with disabilities.

◆ Percent of Routes Scheduled to Clock Headways

Measure of how easily passengers can remember transit schedules

Focus: temporal availability

Modes: fixed-route

Scope: system

System Size: any

Audience: public, decision-makers, schedulers

Description: A clock headway is one that is evenly divisible into 60 minutes, so that a transit vehicle always arrives at the same time past each hour. Examples of clock headways are 10, 12, 15, 20, 30, and 60 minutes.

Major factors: Transit demand, route length, labor and equipment efficiency targets

Data requirements: Scheduling information

Assessment: Clock headways are easier for passengers to remember and thus make the system easier to use when headways are relatively long. The need for clock headways must be balanced against labor and equipment efficiency, for example, when clock headways would result in excessively long layovers or require extra vehicles. At short headways (under 10 minutes), service is frequent enough that passengers do not need to consult schedules, and the need to schedule to clock headways is minimal.

◆ Percent Person-Minutes Served

Average percent of time that transit service is available within a given area

Focus: spatial and temporal availability

Modes: all

Scope: stop, route, subarea, system

System Size: any

Audience: decision-makers, transit management, MPOs/transportation planners

Description: Service coverage measures indicate where service is offered, but not how often or how long. Similarly, temporal availability measures indicate how long or how often service is provided but not where. To provide a combined measure of spatial and temporal availability, the Florida DOT developed a "Florida Transit Level of Service (TLOS) Indicator" that uses *percent person-minutes served* as its basis. At a stop, this measure reflects the average percentage of time that service is provided at that stop. Along a route or street, the measure also reflects relative population and employment densities and pedestrian environment factors. At a sub-area or system level, the measure reflects the average percentage of time over a given period (15 minutes to a week) that a person has access to the transit mode, reflecting both areas that have no service (and no person-minutes served) and areas that do.

Example target values: For TAZ 263 in Tallahassee, Florida, from 7:00 a.m. to 7:59 a.m. using walk buffers: transit service was available for 7,442 person-minutes out of 109,800 total possible person-minutes. Percent person-minutes served is 7%.

Major factors: Transit stop and route spacing, service frequency, hours of service, pedestrian environment, street and pathway connectivity, population and job density relative to the amount of service provided

Data requirements: Data requirements increase as the analysis scope increases. All analysis types require the user to define walk distances (5 minutes recommended for bus stops, 10 minutes for rail and busway stations) and wait times (5 or 10 minutes recommended). Wait time reflects the window of opportunity provided by each transit vehicle to access transit—if service is provided once an hour and a bus is missed, that passenger would not have access to transit at that particular minute.

At the stop level, the measure can be calculated with pen and paper. A bus schedule can provide arrival times at a stop or headways between buses.

At the route level, FDOT provides a spreadsheet. Bus schedule data, stop spacing, relative population and job densities at stops, and (optionally) pedestrian environment data are required. An average accessibility value is reported for both population and jobs. Smaller cities (under 50,000 population) with simple route networks can use the spreadsheet in combination with GIS software (to create service coverage areas around stops) to measure availability.

At the system level, FDOT provides Windows-based software. ARC/INFO is also required to generate the walk and air "buffers" representing each stop's service coverage area. Required GIS layers consist of street and pathway networks, transit stop and route locations, and population and job data by traffic analysis zone (TAZ) or census block. Optionally, pedestrian environment data can be provided. Population and job accessibility results can be reported by air or walk buffer, TAZ, groups of TAZs (e.g., representing neighborhoods, cities, or council districts), or for the entire city.

Assessment: The TLOS Indicator provides a method of reporting transit availability using a single measure. As with any measure that incorporates multiple factors, it cannot be determined directly from the result whether any of the individual factors (i.e., service coverage, frequency, hours of service, and pedestrian environment) have problems that require attention. The measure is relatively easy to apply up to the route level, but a system-level use requires a significant investment in time and data collection. Updating the software's database is generally not labor-intensive, but can require lengthy (multiple days for a large system) computer calculations, depending on the size of the area, the computer's speed and amount of available memory. TLOS Indicator values can be converted into equivalent levels of service, based on the TCQSM's *frequency* and *hours of service* LOS thresholds. The Florida DOT is continuing to enhance the software, most recently adding *travel time* calculation capabilities between addresses, stops, and TAZs. It is currently working on a stop-level ridership forecasting model.

The *Transit Service Accessibility Index* is a related measure that focuses on the amount of service provided to potential trips. Both measures provide the ability of calculating *mode splits* that reflect the number of people who use transit service when it is available as an option to them.

Reference: FDOT Public Transit Office (***40***)

◆ Transit Service Accessibility Index

The number of trip ends exposed to transit service

Focus: spatial and temporal availability

Modes: all

Scope: zone, system

System Size: any

Audience: decision-makers, transit management, MPOs/transportation planners

Description: The Transit Service Accessibility Index measures the number of person trips per week that have transit service available at a trip end. It ties travel demand to available transit supply, and it accounts for demand variations across the day. Calculating the transit service availability index is a four-step process that uses a spreadsheet:

1. *Temporal allocation*—percent of daily trips occurring each hour;
2. *Service supply*—hours of service, frequency, and maximum desired passenger wait time;
3. *Geographical route coverage*—the percentage of each zone's trip generation that can access a given route; and
4. *Index calculation*—requires each zone's population, employment, and a relative trip generation weight for weekdays, Saturdays, and Sundays.

The number of daily trips in a given zone is based on the sum of the daily trips per hour. The zonal totals can be aggregated to develop a systemwide total, and this value can be converted into a per capita transit availability rate.

Example target values: In Tampa, the per capita transit availability rate (total trips exposed to transit per day divided by area population) was 0.095. The percentage of trips possible by transit, assuming 4.2 trips per person per day, was (0.095/4.2*100), or 2.3%. Transit's mode split in Tampa is 0.7%, from which it can be calculated that 30% (0.7/2.3) of all trips in which transit was an option were made by transit.

Major factors: Transit stop and route spacing, service frequency, hours of service, population and job density and timing of trips relative to where and when transit service is provided

Data requirements: Transit schedules, daily trip generation by TAZ, population by TAZ, employment by TAZ, transit route network, proportion of daily trips made each hour

Assessment: The Transit Service Accessibility Index has similarities to the Florida Transit Level of Service Indicator and could be calculated by applying hourly trip generation rates to hourly TLOS values. However, the TLOS Indicator is a measure of service supplied, while the Transit Service Accessibility Index is a measure of how well service demanded is served.

It would be difficult to justify late-night welfare-to-work service from this measure with the National Personal Transportation Survey (NPTS) data used as a spreadsheet default. The number of overall trips made between 11 p.m. and 6 a.m., for example, is only 3.27% of the total daily trips, so adding late-night service would expose very few additional trips to transit service.

The Tampa mode split results are similar to those obtained by the TLOS pilot project in Tallahassee, where 11% of trips having transit as an option (spatially and temporally) were made by transit, compared to a traditional mode split of 0.7%. The adjusted mode split result depends in large part on the value assumed for desired passenger wait time but is still considerably larger than the traditional mode split, regardless of the value selected. Either of these measures could be used by an agency to counter critics who, based on mode split data, claim that transit service is not well used.

Reference: Navari (***44***)

◆ Transit Accessibility Index

The ease and convenience of reaching a destination by transit; considers total travel time between O-D pairs, transit fare, and out-of-pocket cost for autos

Focus: spatial and temporal availability

Modes: compares bus, auto, and bicycle

Scope: corridor

System Size: small, medium

Audience: decision-makers, transit management, MPOs/transportation planners

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Description: This is a set of indexes (one for travel time and another for travel costs) that evaluate door-to-door trips between origin-destination pairs. These indexes can be used for service equity comparisons between areas, direct comparisons of modes, and comparisons of alternative travel time and cost scenarios. The accessibility index for bus travel time is

$$\frac{Time\ by\ Bus}{\frac{1}{2}(Time\ by\ Car + Time\ by\ Bus)}$$

The accessibility index for bus travel cost is calculated similarly.

Example target values: In Schoon, McDonald, and Lee's pilot study, the travel time accessibility index for bus is 1.3 and for car is 0.67. The travel cost accessibility index for bus is 1.2 and for car is 0.95.

Major factors: Travel times and costs (for bus, auto, and bicycle), service coverage, frequency, and hours of service (bus)

Data requirements: Distances between origins and destinations; bus, auto, and bicycle speeds; bus, auto, and bicycle travel times; walking times; walking distances; waiting times; fares; out-of-pocket operating costs; average vehicle occupancy

Assessment: This measure appears most useful for corridor analyses. It can be very detailed depending on how the O-D pair is specified (e.g., walking time between bicycle racks and the destination is considered), and how precise the distance measurements are (e.g., air distances vs. walking distances along links). On the other hand, total travel times are based on average speeds, not real-time travel times. Calculation of the measure produces absolute as well as relative travel times between modes. The measure applies to transit routes providing the most frequent service within a corridor. A single corridor analysis should be fairly simple to perform; a regional picture of accessibility might be developed from corridor analyses, but more O-D pairs would intensify the data collection and calculation effort. The outputs are unweighted (and therefore not likely to be biased); but subjective measures such as comfort and perceived reliability are not included, so the measure probably will not indicate traveler choices. Output could be shown graphically with tables and charts; samples are provided in Schoon, McDonald, and Lee's paper.

Reference: Schoon, McDonald, and Lee (***45***)

◆ Local Index of Transit Availability

A measure of "transit service intensity," based on capacity, frequency, and route coverage

Focus: spatial and temporal availability

Modes: bus and rail

Scope: system, region

System Size: any

Audience: transit service planners, land use planners, policy-makers

Description: The LITA score is composed of standardized measures of capacity (seat-miles divided by total residential and employment population), frequency (the average number of transit vehicles per 24-hour day, including weekends), and route coverage (transit stops per developed square mile), which are applied to zones within a metropolitan area. Values for a specific analysis zone are evaluated relative to the mean for the entire metropolitan area under study. Level of service grades can be assigned to the zone LITA score based on incremental standard deviations away from the mean score. Direct comparisons between metropolitan areas cannot be made.

Example target values: The LITA score for an average zone will be zero. A positive score indicates the number of standard deviations a zone's score is above the mean; a negative score indicates standard deviations below the mean. A constant, such as 5, can be added to LITA scores so that all results are positive values. Level-of-service grades ("A" through "F") can be assigned to LITA ranges (e.g., 6.5+ = "A", 5.5 to 6.5 = "B", 4.5 to 5.5 = "C", ..., No Service = Level of Service "F").

Major factors: Transit vehicle size, route miles, development patterns, service frequency, hours of service, transit stop spacing

Data requirements: Population, employment, and land area data (preferably by census tract, transportation analysis zone, or some smaller zone); seat-miles of transit service by zone; number of transit vehicles per week by zone; number of transit stops by zone; spreadsheet software; data from at least 50 zones

Assessment: Detailed instructions and an example application are provided in Rood's paper. These show that the measure is easy to calculate if the data are readily available and easily broken down by zone. The level of detail will depend on the size of the analysis zones. The capacity, frequency, and route coverage components of the LITA score could be weighted if necessary. The capacity and frequency components are somewhat related, as the number of seat-miles increases with frequency.

Reference: Rood (***46***)

◆ Index of Transit Service Availability

A planning-level measure of metropolitan area transit service availability

Focus: spatial and temporal availability

Modes: bus, rail

Scope: system, metropolitan area

System Size: any

Audience: MPOs/transportation planners

Description: This measure is a planning tool that allows the comparison of transit service availability over time between metropolitan areas with similar demographic characteristics. It includes a service coverage component (directional route-miles per square mile), a frequency component (vehicle-miles per directional mile), and a system-capacity component (seat-miles per capita). All components are normalized and unweighted in the ITSA calculation.

Example target values: Henk, et al. calculate ITSA values for 228 cities. Sample cities are New York City (ITSA = 7.5), San Francisco (6.6), Atlanta (6.6), Portland, OR (5.2), Los Angeles (4.7), St. Louis (4.4), Houston (5.0), Kansas City (4.7), Phoenix (4.5), and Charlotte (6.1).

Major factors: Service coverage, service frequency, system capacity, availability and reliability of demographic and NTD data, correlation between ITSA components, stratification scheme for grouping metropolitan areas

Data requirements: Population, land area, route-miles, vehicle-miles, and seat-miles by metropolitan area

Assessment: The index is simple to compute and understand and is based on readily available data. The three selected component measures were those with the least redundancy of over 30 possible measures. The ITSA components are unweighted. Population density reflects the metropolitan area, not the transit service area; it is also an average, so the ITSA is clearly macroscopic. The metropolitan area may include several transit providers with different service goals. The stratification scheme can potentially bias comparisons and/or oversimplify. Henk et al. note that Section 15 (NTD) data may not be completely reliable.

Reference: Henk, et al. (***47***)

◆ Number of Fare Media Sales Outlets

The number of locations away from transit stops and stations that sell transit fare media

Focus: spatial and temporal availability

Modes: all

Scope: system

System Size: any, but more useful to larger systems

Audience: public

Description: This is a count of the number of locations where customers may purchase transit fare media, excluding outlets located at transit stops and stations. This is particularly important for passengers who wish to purchase long-term fare media (e.g., monthly passes) or specialized media (e.g., senior passes) that may not be available for purchase through ticket machines. Sales outlets can include agency pass-by-mail or online sales programs.

Example target values: MTA-NYCT measured its efforts to provide "a more effective network of out-of-system fare media distribution channels" by the percent of daily trips made via MetroCards purchased out-of-system. The 2000 goal was 13% of trips; 15% of trips in 2000 were made via MetroCards purchased out-of-system.

Major factors: Success in signing up outside vendors to sell fare media, agency ability to sell fare media by mail or over the Internet

Data requirements: Records of sales outlets to which transit fare media are supplied. A measure similar to MTA-NYCT's also requires tracking fare card serial numbers and card usage.

Assessment: This is a measure of how easily fare media (particularly discounted and multiple-ride media) are available to potential customers. It is particularly important to infrequent local users, as well as visitors to an area, who may not be familiar with the system's fare structure nor have exact change. Having external sales outlets can also save time for regular customers who would otherwise have to wait in line at ticket machines. The greater the number of sales outlets, the greater the convenience for customers, who otherwise would have to make a longer average trip to a smaller number of sales outlets.

◆ Service Denials

The percentage of trip requests in which service cannot be adequately provided

Focus: paratransit availability

Other Uses: capacity, service monitoring, service contracting, ADA accessibility, community, paratransit

Modes: demand-responsive service, specifically ADA complementary paratransit

Scope: system

System Size: any

Audience: public; decision-makers; federal government, including FTA, DOJ, and federal courts

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Description: A service denial is specifically defined by the ADA as failure to provide a scheduled trip within an hour of either side of the requested time to travel. Should no trip be available in that 2-hour "window," the request for service is termed a "denial."

Example target values: MTA-NYCT Paratransit Services had 125,654 denials citywide in 1998.

Major factors: Service hours available, level of peak-hour and peak-day demand, available vehicles, available drivers

Data requirements: Scheduling software records of all trip requests, reservation agent logs

Assessment: Service denials should be measured as the number of denials divided by a total of trip requests (all or casual). A pattern or practice that allows for a substantial number of service denials is forbidden under the ADA, for ADA paratransit services. A pattern of denials of paratransit service during an agency's prescribed reservation period, specifically including next-day reservations, is seen under the ADA as a capacity constraint.

Denials have been used by transit agencies as a means to control and limit demand. They can be effective in controlling demand, improving service productivity, and significantly reducing service costs of general demand-responsive service. However, transit agencies should note that this technique is only permissible for general demand-responsive service.

Using service denials to control and limit demand on ADA service can expose a transit agency to significant and costly litigation. Recent court rulings have sided strongly against the existence of capacity constraints in Philadelphia and Syracuse.

Reducing a significant denial rate to a near-zero denial rate is usually highly costly unless other demand management measures are taken, since demand increases and the previously denied trips tend to be less productive than the accepted trips.

Whether the service is an ADA complementary paratransit system or a general demand-responsive system, a high level of denials means that service is inadequate to meet demand. Financial constraints are usually a primary reason that demand is not expanded by additional vehicles and drivers.

Comments: The TCQSM Second Edition will introduce a *trips not served* LOS measure for demand-responsive transit that combines *service denials* (trips not able to be scheduled at the desired time) with *missed trips* (trips that were scheduled but service not provided at the promised time).

◆ Pass-Ups

The number of passengers unable to board a crowded transit vehicle when it arrives at a stop

Focus: capacity availability

Other Uses: service monitoring, travel time

Modes: all fixed-route

Scope: stop, route, system

System Size: any

Audience: public, decision-makers, service planners

Description: A pass-up occurs when (1) one or more passengers chooses not to board a bus because of the level of crowding inside or (2) an operator bypasses a stop because there is no more room inside the vehicle to board additional passengers.

Example target values: MUNI's goal for its five most patronized routes is to have fewer than 5% of full vehicles pass a published time point without stopping, unless another vehicle on the same route with space for the waiting passengers follows within 3 minutes.

Major factors: Person capacity of transit vehicles, frequency, passenger demand peaking characteristics, transit vehicle bunching

Data requirements: Operator logs, AVL equipment (where the operator manually indicates that pass-ups have occurred), or customer or on-board surveys. Determining whether passengers are being passed up may be difficult if more than one route uses a particular stop. Some AVL systems can be programmed to allow vehicle operators to indicate pass-ups, fare evasion, wheelchair lift use, or other events of interest to the agency.

Assessment: Pass-ups are a source of frustration to customers, as their overall travel time increases by the time they must wait for the next vehicle, with no guarantee of space on that vehicle. Pass-ups may indicate the need for schedule adjustments to accommodate passenger demand peaking or for actions to address bus bunching on routes with short headways.

❖ Seat Capacity

Planning-level capacity availability measures

Focus: capacity availability

Other Uses: capacity

Examples: seat miles per square mile, seat miles per capita, seat miles per route mile

Modes: fixed-route

Scope: sub-area, system

System Size: any

Audience: service planners, MPOs/transportation planners

Description: *Seat miles* is the number of seats on a transit vehicle, multiplied by the number of vehicles the vehicle travels in revenue service (including deadheading). It can be divided by the service area population, service area size, and/or route miles to get a planning-level estimate of the capacity offered by the system. *Seat miles per capita* is a component of the *Index of Transit Service Availability*.

Example target values: Washington, D.C., provided 3,350 seat-miles per capita in 1990. Its peer group (i.e., cities with a population density greater than 2,000 and a population greater than 1 million) provided 1,110 seat-miles per capita in 1990.

Major factors: vehicle seat capacity, frequency, hours of service, route lengths, service area population

Data requirements: Number of seats provided on transit vehicles, number of miles traveled by each vehicle in revenue service, population data

Assessment: These measures provide a generalized indication of the capacity provided by a system. *Route coverage* and *vehicle capacity* are similar types of measures. They are not intended to assess whether enough capacity is provided on a particular route.

SERVICE DELIVERY MEASURES

Service delivery measures assess passengers' day-to-day experiences using transit. Even when transit service is available to someone, if a trip by transit is inconvenient or uncomfortable, a person with a choice will likely choose another mode. This section divides service delivery measures into four main sub-categories:

1. *Reliability*—how often service is provided when promised;
2. *Customer service*—measures assessing the quality of direct contacts between passengers and agency staff, and overall measures of service quality;
3. *Passenger loading*—measures of the level of crowding on transit vehicles; and
4. *Goal accomplishment*—how well an agency has achieved its shorter-term project goals.

Comfort measures span several categories and are listed in the index of performance measure categories.

Many other measures discussed elsewhere in this summary also have some relationship to service delivery:

- Service hours,
- Revenue hours,
- Response (access) time,
- Service denials,
- Pass-ups,
- Customer satisfaction,
- Travel time,
- Reliability factor,
- Delay,
- Relative delay rate,
- Travel rate index,
- System speed,
- Accident rate,
- Road calls,
- Fleet cleaning,
- Customer impact index,
- Ridership,
- Passenger miles traveled,
- Cost-effectiveness,
- Productivity,
- Mobility index,
- Fleet maintenance performance,
- Maintenance program performance, and
- Number of late cancellations/no-shows.

◆ On-Time Performance (Fixed-Route)

The percentage of transit vehicles departing or arriving at a location on time

Focus:	reliability
Other Uses:	service contracting
Modes:	any fixed-route service operating on a fixed schedule (as opposed to fixed headways)
Scope:	stop, route, system
System Size:	any
Audience:	public, decision-makers, transit management

Description: A transit vehicle is considered "on time" if it departs a location within a certain number of minutes after and/or before the scheduled time. Many agencies consider an early departure not to be on time, to discourage operators from leaving a stop "hot." From a passenger point of view, an early departure means a wait of one headway for the next vehicle.

The window of time considered to be on time varies considerably from one agency to another; *TCRP Synthesis of Transit Practice 10* (***48***) reported most agencies were in the range of 1 minute early to 5 minutes late, but 42% of agencies used a value greater than 5 minutes late for on time, and 8% used a value greater than 5 minutes early for on time. The most common definition, and the one used in the TCQSM (***2***), is 0 minutes early to 5 minutes late.

On-time performance is usually measured only for specific locations (timepoints) for which a schedule is published. However, ideally, it could include all en route stops, for regular bus and subway service. If most passengers board at the terminal and alight at the end of the line (as with some commuter or light rail services), then terminal on-time performance would be important. Some agencies measure on-time performance at one or two intermediate timepoints (for example, the third and fourth out of five), in cases where most passengers would have alighted before the end of the line. The causes of early or late vehicles can also be categorized and reported, as MTA-NYCT does.

Performance may be weighted by stop according to ridership, as proposed by Henderson, Adkins, and Kwong; *passenger-weighted on-time performance* measures the percent of passengers on time instead of the percent of transit vehicles on time. Henderson, Adkins, and Kwong tested the concept with subways and gave the heaviest weights to train stations that had the highest number of riders. They concluded that the results were no different from the standard method.

Example target values: *TCRP Synthesis of Transit Practice 10* reports on-time performance standards for 83 agencies. The first edition of the TCQSM applied a curve to these standards to develop the following on-time thresholds: "A" = >97.5%, "B" = 95.0-97.4%, "C" = 90.0-94.9%, "D" = 85.0-89.9%, "E" = 80.0-84.9%, "F" = <80%. Higher on-time performance values are easier to meet with a more lenient definition of on time. From a passenger point of view, the standards are reasonable (e.g., a passenger making a round-trip commute by transit every weekday would be more than 5 minutes late twice a week). From an agency point of view, the TCRP A-15A project found that the LOS thresholds were consistent with adopted agency on-time standards, but also found through test cases that when the measures were applied system-wide, agencies had difficulty achieving non-LOS "F" service. However, in many of these cases, the reason for the poor on-time performance was either due to (1) significant amounts of early running or (2) a failure to adjust scheduled running time from off-peak to peak conditions. If these factors, under the control of an agency, were corrected, then the on-time performance LOS thresholds would be achievable.

Major factors: Traffic congestion, number of stops, passenger volumes, schedule accuracy, operator diligence, operator availability, driver motivation, supervision, degree of right-of-way control, length of route, maintenance practices, and mechanical problems. Henderson and Darapaneni write that the number of route merges, whether public schools are in session, scheduled headway, distance traveled, stops, crowding, and overnight construction are factors that influence subway on-time performance.

Data requirements: Field surveys (e.g., by traffic checkers performing point checks or ride checks) or automatic vehicle location (AVL) data. The measure requires a relatively large number of observations to draw meaningful conclusions, especially if route-level or stop-level results are desired. Usually, a 95% confidence level and a margin of error of ±5% would be desired. Drawing a distinction between the current TCQSM "A" and "B" levels of service would require a minimum of 40 observations to achieve the 2.5% resolution.

Assessment: This measure can be used both diagnostically and as a tool to assess the experience of customers. Since substantial data collection efforts are necessary, manual data collection can become quite expensive as well as error-prone. If data collection is automated, route-level and even operator-level performance can be determined. Note that precision (e.g., accuracy of checker watches) is important since even one minute early is considered by some agencies as not on time.

On-time performance is often measured only on routes with longer headways (e.g., longer than 10 minutes), while *headway regularity* is often measured for routes with shorter headways. At shorter headways, customers do not have to rely on schedules, as the wait time for the next vehicle should be short; so the actual time that a vehicle arrives at a passenger's origin is less important to customers. At the same time, a longer-than-expected interval between vehicles leads to longer waits for customers, a more crowded vehicle when it does show up, and, potentially, a slower trip. Even when *headway regularity* is measured, on-time performance still provides a useful indication of whether passengers get to their destination on time, which is reflective of in-vehicle *travel time*.

Total trip on-time performance, proposed by Henderson, Adkins, and Kwong, combines travel times and wait times. A transit vehicle is late if actual travel time plus actual wait (which is half the headway) exceeds the scheduled travel time plus scheduled wait by more than 5 minutes. Passengers are late if (ATR + AW) – (STR + SW) > 5 minutes where ATR = actual travel time; AW = average actual wait or one-half the actual headway; STR = scheduled travel time; and SW = average scheduled wait, or one-half the scheduled headway. Automated data from AVL or automated train control system and related APTS software would be of great help in collecting data to calculate this measure. Henderson, Adkins, and Kwong develop this concept further by assuming that trains with longer headways will be more crowded and will affect a greater number of passengers. On-time performance is, therefore, the total number of passengers on time divided by the total number of passengers late and on time. Results of the weighted total trip method were lower than results of the total trip method. Henderson, Adkins, and Kwong also propose the calculation of average delay by imputing delay times to cancelled trains.

Comments: The TCQSM Second Edition is expected to adjust the LOS thresholds so that each LOS covers a 5% range (i.e., the "A"/"B" threshold would be at 95% and the "E"/"F" threshold would be at 75%). This change reduces the amount of data collection needed to distinguish between two levels of service.

References: Henderson, Adkins, and Kwong (***49***); Henderson and Darapaneni (***50***)

◆ On-Time Performance (Demand-Responsive)

The percentage of pickups and/or drop-offs made within a designated service window

Focus:	reliability
Other Uses:	service contracting, paratransit, ADA accessibility
Modes:	demand-responsive
Scope:	system
System Size:	any
Audience:	public, decision-makers, transit management

Description: On-time performance as measured in demand-responsive service means that service should be provided within a reasonable period before or after the agreed-upon pickup time. A trip is normally measured as late when it is later than the acceptable service window. Service windows vary significantly from system to system. In some situations, such as medical appointments or transportation to job sites, a passenger's arrival time may be equally, if not more important, than the pickup time.

Example target values: Possible service windows: 0 to 20 minutes from scheduled pickup time, 0 to 30 minutes, 10 minutes prior and 10 minutes after scheduled pickup time

Major factors: Traffic congestion, inclement weather, system speed, reasonability of scheduling parameters, number of no-shows, vehicle reliability, availability of relief/additional vehicles

Data requirements: AVL, scheduling dispatch reports, or driver logs

Assessment: This is one of the most visible measurements in the realm of customer service quality, service availability, and ADA accessibility. A significantly low on-time performance has been viewed as a potential capacity constraint and has been presented as such in litigation. On-time performance can be used to measure a contractor's service quality. The measure can be used for financial rewards or penalties when the contractor also operates service delivery, reservations, scheduling, dispatch, and vehicles.

Many factors affect on-time performance, and improving it can be costly since it usually involves devoting more service hours to transporting an equal number of passengers. A more effective and less costly way to improve on-time performance is to improve scheduling through better routing and grouping and to reduce no-shows.

Comments: The TCQSM Second Edition is expected to provide a separate on-time performance LOS measure for demand-responsive transit, using a numerical (e.g., 1-8), rather than an alphabetical (e.g., A-F), LOS scale. The measure would be applied to all pick-ups and time-sensitive drop-offs (e.g., medical appointments, work and school trips).

❖ Headway Regularity

The evenness of intervals between transit vehicles

Focus: reliability

Examples: service regularity, headway adherence, headway regularity index, wait assessment, headway ratio, headway deviation

Modes: bus and rail operating at fixed headways

Scope: stop, route, system

System Size: any

Audience: public, decision-makers, transit management

Description: *Headway adherence* is used by the TCQSM as the measure of reliability for service scheduled for headways of 10 minutes or less. It is defined in the First Edition as the coefficient of variation of headways (the standard deviation of headways divided by the scheduled headway), but it is expected to be changed in the Second Edition to be the coefficient of variation of *headway deviations* divided by the average scheduled headway. This change corrects a problem wherein the original measure could be used only if the scheduled headway was the same throughout the analysis period.

Service regularity is the percentage of headways that deviate no more than a specified amount from the scheduled interval. According to MTA-NYCT's definition, a transit vehicle was considered "regular" if it is within ±50% of the scheduled interval (for intervals of 10 minutes or less) or within ±5 minutes of the scheduled interval (for intervals greater than 10 minutes). MTA-NYCT has replaced *service regularity* with *wait assessment*, which is defined as the percentage of headways no more than 3 minutes longer than the scheduled headway.

Headway ratio is the observed headway divided by the scheduled headway, multiplied by 100. A value of 100 shows that the scheduled headway and actual headway are equal. A value not equal to 100 represents deviation from the scheduled headway.

Henderson, Kwong, and Adkins proposed a *headway regularity index* using Gini's ratio. A high value indicates regular service; a low value indicates irregular service. The following formula is used:

$$R = 1 - 2\text{*Sum of }(hr - H)\text{*}r \,/\, n^2 H$$

Where hr = series of headways; $r = 1 \ldots n$, the rank of headways from smallest to largest and H = mean headway.

The *headway deviation* is the number of minutes that a transit vehicle is off headway (actual headway minus scheduled headway). It can be used as an input to other measures (e.g., *wait assessment*) or combined with average passenger loading data to estimate the amount of extra time that passengers spend waiting for transit vehicles.

Example target values: *Service regularity:* 85% for peak conditions and 90% for off-peak. The TCQSM First Edition defines the following LOS ranges for *headway adherence*: "A" = 0.00-0.10, "B" = 0.11-0.20, "C" = 0.21-0.30, "D" = 0.31-0.40, "E" = 0.41-0.50, "F" = >0.50.

Major factors: Traffic congestion, number of stops, passenger volumes, schedule accuracy, operator diligence, operator availability, and mechanical problems. For subways, Henderson writes that the number of route merges, whether public schools are in session, scheduled headway, distance traveled, stops, crowding, and whether construction occurred the night before are also factors.

Data requirements: Field surveys (e.g., by traffic checkers) or automatic vehicle location (AVL) data. A relatively large number of observations are required to draw meaningful conclusions, especially if route- or stop-level results are desired. Both headway regularity and *on-time performance* data can be collected simultaneously; the same datapoints can be used to calculate both.

Assessment: Since substantial amounts of data are necessary, manual data collection efforts can become quite expensive. If data collection is automated, route-level and even driver-level performance can be determined. Note that precision (e.g., accuracy of checker watches) is important.

Less-statistical measures such as *service regularity, wait assessment,* and *headway ratio* are easier to explain to the public and decision-makers. The *headway regularity index* does a better job of identifying vehicle bunching but is not as easy to explain or visualize. *Headway ratio* assumes that headways between vehicles are scheduled to be the same over the analysis period. The TCQSM Second Edition's definition of *headway adherence* seeks to address these issues: the new definition still does a good job of identifying vehicle bunching, allows variable scheduled headways, and ties the LOS thresholds to the probability that any given vehicle arrival will be more than one-half headway off its scheduled headway. This is easier to explain than simply presenting ranges of a statistical measure.

Headway regularity is important to monitor for high-frequency transit services, particularly in relation to vehicle bunching. Bunching reduces the amount of usable passenger capacity provided, increases passenger loads on the first vehicle in a bunch (as it picks up its passengers as well as passengers that would normally have caught the next vehicle), increases passenger wait times, and increases overall travel times, particularly for passengers on an overcrowded vehicle.

On-time performance is often measured only for routes with longer headways (e.g., longer than 10 minutes), while *headway regularity* is often measured for routes with shorter headways. At shorter headways, customers do not have to rely on schedules, as the wait time for the next vehicle should be short; so the actual time that a vehicle arrives at a passenger's origin is less important to customers. At the same time, a longer-than-expected interval between vehicles leads to longer waits for customers, a more crowded vehicle when it arrives, and potentially a slower trip. Even when *headway regularity* is measured, on-time performance still provides a useful indication of whether passengers get to their destination on time, which is reflective of in-vehicle *travel time*.

References: Henderson, Kwong, and Adkins (headway regularity index) (***51***)
TCQSM (headway adherence) (***2***)

◆ Missed Trips

Trips removed from the daily schedule

Focus: reliability

Other Uses: paratransit

Modes: all

Scope: route, system

System Size: any

Audience: transit agency maintenance, planning, scheduling, and human resources departments

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Description: Missed trips can occur due to mechanical breakdowns or driver absences. They can have a negative impact on the perceived reliability of transit service and can result in long wait times, missed transfers, etc. Missed trips can also reflect inefficiencies in service. In demand-responsive service, a *missed trip* occurs when a trip is scheduled, but no vehicle shows up to collect the passenger. For ADA services, a pattern or practice of missed trips indicates a capacity constraint that is not allowed.

Example target values: For MTA-NYCT buses, July 2001 had 98.66% completed trips. Trips were missed due to bus defects and breakdowns (0.49%), unavailable operators (0.08%), service adjustments to maintain service regularity (0.74%), and miscellaneous causes such as sick passengers (0.03%).

Major factors: Vehicle condition (e.g., maintenance history and age), quality of maintenance program, operator reliability

Data requirements: Schedule, incident/dispatching logs

Assessment: Missed trips are easy to track and affect passenger satisfaction and system productivity. While measures such as *on-time performance* and *headway regularity* present general assessments of system reliability, *missed trips* is a measure that can be used internally by an agency to monitor one of the factors that influences the broader measures.

Comments: The TCQSM Second Edition will introduce a *trips not served* LOS measure for demand-responsive transit that combines *missed trips* (trips scheduled but not provided at the promised time) with *service denials* (trips unable to be scheduled at the desired time).

❖ Lost Service

Measures of service reliability impacts of trips not made

Focus: reliability

Examples: lost time, percent lost hours

Modes: all

Scope: route, system

System Size: any

Audience: transit managers, service planners

Description: *Lost time* is the revenue hours lost between when a vehicle ceases service (due to a mechanical breakdown or other reason) and when the vehicle resumes or is replaced in service. *Percent lost hours* is a measure of the scheduled revenue hours that were not provided or dispatched. It is similar to *missed trips*. The converse measure is *percent of scheduled vehicles placed into service*.

Example target values: MUNI goals for *percent lost hours* are 3.5 percent in Fiscal Year 2001, 2.5 percent in Fiscal Year 2002, 2 percent in Fiscal Year 2003, and 1.5 percent in 2004.

Major factors: Vehicle condition (e.g., maintenance history and age), quality of maintenance program, operator reliability

Data requirements: Schedule, incident/dispatching logs

Assessment: These measures are relatively easy to track, are objective, can be tracked to specific vehicles/routes, and reflect impacts on passengers and productivity.

◆ Percent of Scheduled Vehicles Placed into Service

Measure of service reliability, based on the number of trips made

Focus: reliability

Modes: all

Scope: operating division, system

System Size: any

Audience: transit managers, service planners

Description: This measure is the percentage of scheduled buses that were actually placed into service.

Example target values: In its March 2001 "State of the Bus System" report, LACMTA reported that 99.5% of scheduled buses were placed into service every day. In 1998, only 97% of buses were placed into service. San Diego MDTB's *percent of scheduled service* goal is 99.5%.

Major factors: Vehicle condition (e.g., maintenance history and age), quality of maintenance program, operator reliability

Data requirements: Schedule, incident/dispatching logs

Assessment: This measure provides little detail on the actual service provided to riders. How long was the bus out of service? When was another vehicle dispatched to replace it? To what extent was scheduled service disrupted? How many trips were missed? How much were passengers delayed? Measures such as *lost service* and *missed trips* do a better job of answering these questions, are more passenger-oriented, and are tied more to route- and stop-level service. However, this measure does have an advantage over the other two in that it is a positive measure: it reports how often an agency succeeded (e.g., 99.5% of the time), rather than how often it failed.

◆ Scheduled Miles per Minute of Delay

Measure of the effects of incidents on service reliability

Focus: reliability

Modes: fixed-route

Scope: route, system

System Size: any

Audience: transit dispatch staff, supervisors

Description: This measure is intended to identify how well incidents are managed and how the effects of missed trips and delays are minimized. It is more dispatch-oriented than maintenance- or schedule-oriented.

Major factors: Communication media and speed, experience, number of personnel, degree to which the agency can control incidents

Data requirements: Scheduled miles, incident logs

Assessment: This measure is useful when reviewing incidents. It does not reflect the passenger point of view directly in the sense that it is not a measure of the immediate—passengers do not always see the agency's efforts to minimize incident delay, and passengers are not necessarily concerned with scheduled service beyond their own trips.

❖ Equipment Reliability

Measures of station and vehicle access and usability

Focus: reliability

Other Uses: ADA accessibility, availability

Examples: average percent of time elevators/escalators are in service, average number of stations with out-of-service elevators/escalators, wheelchair lift failure rate, percent of time ticket machines in service

Modes: all (lift failure rate); busway, rail (station-related measures)

Scope: route, system

System Size: any (typically large for station-related measures)

Audience: public, transit agency maintenance departments

Description: Persons who use wheelchairs or strollers, carry luggage, have difficulty climbing stairs, etc., require functional elevators in stations where vertical movement is required between street, lobby, and/or platform levels. If an elevator is out of service, the station may be inaccessible to these persons. Out-of-service escalators may require long walks up or down flights of stairs or stopped escalators, which are more difficult to climb and descend. When wheelchair lift failures occur, passengers must either wait for the next vehicle or have a paratransit vehicle dispatched to serve them. Either option means wasted time for the passenger; and the time spent waiting may not be comfortable, depending on the shelter available at the stop. When ticket machines fail, longer lines develop at the remaining machines; and passengers may miss the first transit vehicle that arrives or may forego paying if a proof-of-payment system is being used. Depending on the mix of machines provided at a station, certain options (e.g., having change returned) may not be available to passengers when a machine failure occurs.

“Average percent of time” measures are calculated using the amount of time that equipment is out of service, compared to the total amount of time that the feature is intended to be in service (e.g., the length of a service day at a stop or location). The *wheelchair lift failure rate* is calculated as the number of lift failures, divided by the total number of times lifts were requested to be used.

Example target values: MTA-NYCT’s subway elevator reliability goal in 2000 was 97.0%. Its actual elevator reliability was 98.6%. The agency’s subway escalator reliability goal in 2000 was 96.0%. Its actual escalator reliability was 97.2%.

Major factors: Equipment condition (e.g., maintenance history and age), quality of maintenance program

Data requirements: Repair logs, schedule information (to determine length of service day), wheelchair lift usage logs

Assessment: Grade-separated rail services (and busways where passengers are not allowed to walk across the busway) require vertical movement to get to and from the platform. If an elevator is not functioning, some passengers will be unable to use the station or, at a minimum, will find the station more difficult to traverse. ADA passengers will require alternative transportation, which typically costs more per passenger trip than a trip on regular fixed-route service; these passengers will also experience delay waiting for the alternative transportation to arrive. Some systems post systemwide elevator availability information at station entrances to minimize the possibility that passengers requiring elevators will arrive at their intended destination, only to find the elevator out of service.

◆ Mean Vehicle Age

The average age of the transit fleet

Focus: reliability

Other Uses: maintenance, comfort

Modes: bus and rail

Scope: system

System Size: any (typically large)

Audience: decision-makers, transit managers

Description: This measure reflects the comfort of the transit vehicle (particularly in terms of air conditioning) and may reflect the reliability of the vehicle (in terms of frequency of breakdowns). Older buses, for example, are less likely to be air-conditioned, are noisier, and are more likely to have worn-out components.

Example target values: Mean vehicle age in Ft. Wayne in 1960 was 13.0 years and in 1967 was 20.0 years. MUNI standards require replacing every motor coach when it reaches 12 years old and replacing every cable car when it reaches 85 years old.

Major factors: vehicle reliability, ADA accessibility requirements, financial resources

Data requirements: Age of each vehicle in the fleet

Assessment: This measure may be biased by the quality of the maintenance program. The measure can be used to track the effects of funding cutbacks: *mean vehicle age* will trend upwards if an agency has insufficient resources to replace older vehicles. It can also serve as an environmental and/or financial indicator, if the fuel economy or emissions of older vehicles are worse than that of newer vehicles.

Mean vehicle age is an indirect measure of potential problems. Other measures such as *fleet composition*, *road calls*, *distance between breakdowns*, and *fleet maintenance performance* will provide more direct indicators of the effects, if any, of older vehicles on passenger comfort, service reliability, and vehicle maintenance and operating costs.

◆ Run-Time Ratio

A service reliability measure based on scheduled and actual running times

Focus: reliability

Other Uses: travel time

Modes: any operating on a fixed schedule

Scope: route

System Size: any

Audience: transit managers, service planners

Description: *Run time ratio* is the ratio of observed running time to scheduled running time, multiplied by 100. This measure is intended to represent uncertainty in transit trips from the passenger's perspective, as variations in running time might result in missed buses, longer waits, etc. It is best used for long routes that include many signalized intersections and other possibilities of delay. The coefficient of variation of the run time ratio can be used to calculate the percentage of trips whose run times will be longer than scheduled. Run time delay can be calculated as a function of departure delay, the number of stops made, route length, total passenger boardings, total passenger alightings, scheduled headway, and scheduled run time.

Example target values: A value of 100 shows that the scheduled headway and actual headway are equal. A value not equal to 100 represents deviation from the scheduled headway.

Major factors: Roadway congestion, dwell time, character of route (number of traffic signals, etc.)

Data requirements: Scheduled and actual running times, number of stops made, route length, boardings and alightings, scheduled headway. The data can be obtained from field data collection, which is labor-intensive, or from APC/AVL equipment.

Assessment: The basic measure is simple to compute, and the distribution of run time ratios can be plotted and studied. The passenger's perspective is represented.

◆ Complaint (Compliment) Rate

The number of passenger complaints or compliments per a specified number of hours, passengers, or trips

Focus: customer service

Other Uses: service contracting

Modes: all

Scope: system

System Size: any

Audience: public, decision-makers, transit managers, customer service staff, operations staff

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Description: These measures report the amount of customer feedback received on the service that was provided over a set period of time. The number of complaints and/or compliments received can be reported as a rate (typically adjusted by a value such as 10,000 hours or 1,000 boardings to avoid reporting very small numbers) or as a simple total.

Example target values: One complaint per 350 paratransit passenger trips is the standard at San Antonio VIA. Seventeen complaints per 100,000 boardings is the standard at Houston METRO. Denver RTD has targets for specific types of complaints, such as less than 1.0 schedule availability complaints per month and less than 5.0 graffiti complaints per month.

Major factors: Actual service quality, customer perceptions of quality of service, customer perceptions of complaint effectiveness, system accessibility, operator training, operator performance, travel time, on-time performance, vehicle comfort

Data requirements: Service hours, boardings, passengers, documented complaints/compliments

Assessment: Complaint- and compliment-based measures are more subjective, as they are a collective measure of customer perceptions. They are based upon only those riders who make the effort to comment. Their perceptions are not necessarily indicative of the service performance perceptions of all riders. However, tracking passenger feedback obtained through a comment process can help an agency obtain useful insights on issues that are important to its customers, without entailing the expense of a customer satisfaction survey.

There are many aspects of the transit trip that could generate comments, from driver courtesy to consistently late vehicles to inadequate air conditioning. Consequently, comments should be grouped by category and evaluated on a monthly basis. Trends, since they are based on more than one comment, can be indicative of where operational strengths and weaknesses exist.

Customers should be fully aware of the commenting process, and there should be multiple means provided for commenting (e.g., postage-paid comment cards in vehicles, Internet-based comment forms, customer service lines, etc.). Prompt feedback to customers is essential, so customers believe that their comments are heard (this can be measured by *customer response time*). If customers believe that they are not being listened to, they may stop providing comments, eliminating a potentially useful source of customer information. Also, the resulting drop in the number of complaints could potentially lead an agency to believe incorrectly that service quality is improving.

◆ Percent of Missed Phone Calls

The percent of total calls to a reservation or information center in which the customer hangs up prior to speaking with an agent

Focus: customer service

Other Uses: service contracting, ADA accessibility, availability, paratransit

Modes: all

Scope: system

System Size: any (typically only medium to large systems will have the necessary equipment to track hang-ups)

Audience: public, decision-makers, transit managers, customer service staff

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Description: This is the number of calls made to a customer service center or paratransit trip reservation center in which the customer hangs up prior to being connected with an agent.

Major factors: Staffing levels, call volume patterns, complexity of interactive voice response prompts, speed of software, availability of other sources to obtain information

Data requirements: Phone-monitoring system for all phone calls, which generates reports indicating calls received, answered, and not answered

Assessment: Large volumes of calls can come into customer service call centers and reservation call centers. Callers can request information, reserve trips, cancel trips, etc. Calls are normally routed through an interactive voice response system, and, if no agent is available to speak, customers are placed on hold. A missed call occurs when a customer hangs up prior to talking to an agent.

Call volumes tend to spike sharply at particular times during the day. It is important to have sufficient staff to meet the demand; but it can be difficult to do so during peak times since the duration of the peak is relatively short. The level of demand for information, etc., is important. Scheduling and other types of software that operate slowly reduce agent productivity and lower the number of calls an agent can process, resulting in longer hold times for customers.

◆ Percent of Calls Held Excessively Long

The percent of phone calls to a call center in which callers wait longer than a specified period of time to speak with an agent

Focus: customer service

Other Uses: service contracting, ADA accessibility, availability, paratransit

Modes: all

Scope: system

System Size: any (typically only medium to large systems will have the necessary equipment to track length of time on hold)

Audience: public, decision-makers, transit managers, customer service staff

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Description: Answering customer inquiries promptly is a normal goal of customer service operations in transit. This measure tracks how often customers must wait beyond a specified amount of time to speak with an agent.

Example target values: Maximum time on hold: 2 minutes. The average MetroCard Telephone Line wait time goal for MTA-NYCT in 2000 was 50 seconds; the actual wait time was 58 seconds.

Major factors: Staffing levels, call volume patterns, complexity of interactive voice response prompts, speed of software, availability of other sources to get information

Data requirements: Phone monitoring system for all phone calls and reports generated from system

Assessment: Large volumes of calls can come into customer service call centers and reservation call centers. Callers can request information, reserve trips, cancel trips, etc. Calls are normally routed through an interactive voice response system and if no agent is available to speak, customers are placed on hold. If a customer hangs up prior to talking to an agent, that is considered a *missed call*.

Call volumes tend to spike sharply at particular times during the day. It is important to have sufficient staff to meet the demand, but it can be difficult to do so during peak times since the duration of the peak is relatively short. The level of demand for information, etc., is important. Scheduling and other types of software that operate slowly reduce agent productivity and lower the number of calls an agent can process, resulting in longer hold times for customers.

ADA paratransit passenger difficulties in scheduling trips have been viewed as de facto capacity constraints in consent agreements, and maximum percentages for customers placed on hold have been mandated. When individuals are unable to access reservations, this can effectively limit service demand; but if an agency chooses to do this, it will likely generate a high level of complaints, negative public perceptions, and the possibility of litigation.

If a service contractor provides reservation services, providing incentives and disincentives for performance can be considered.

◆ Customer Service Response Time

Measure of how quickly customer inquiries are addressed

Focus: customer service

Modes: all

Scope: system

System Size: any

Audience: transit management, customer service staff

Description: This is a customer service measure of how quickly questions are answered and comments and complaints are addressed.

Example target values: Response within 2 working days for phone inquiries; response within 6 working days for letter inquiries. MTA-NYCT's goal for turning around Reduced Fare MetroCard applications in 2000 was 5 business days.

Major factors: Number of customer service personnel, training of customer service personnel, number of questions/comments/complaints, passenger knowledge of the response time

Data requirements: Date and time of inquiry, date and time of response

Assessment: This measure is often applied on a case-by-case basis: either customer service personnel responded in time or they did not. The measure is very passenger-oriented and would work better when passengers are aware of the response policy. Individual cases could be aggregated to produce such measures as *percent of timely responses*.

◆ Driver Courtesy

Customer perception of driver courtesy, friendliness, and sensitivity

Focus: customer service

Other Uses: safety, comfort

Modes: all

Scope: system

System Size: any

Audience: public, decision-makers, transit managers

Description: A rating of driver courtesy, either from a sampling of passenger opinions or through the use of “mystery rider” surveys.

Example target values: 80% positive rating in a customer survey

Major factors: Driver training, overall service quality, system speed

Data requirements: Customer complaints, surveys, secret passengers, and/or focus groups

Assessment: While this performance measure is subjective, it is a fundamental customer service factor. A variety of methods can be used to measure driver courtesy, including tracking customer complaints, conducting customer satisfaction surveys, holding focus groups, and conducting “mystery rider” surveys.

Poor driver service can be indicative of operators who are not doing a good job in other areas, such as service safety. Complaints about drivers can cause significant problems for transit agencies, as these complaints tend to be very strident and very public. Unrealistic schedules may cause drivers to limit their interactions with customers in order to avoid falling behind schedule.

◆ Passenger Environment (Rail)

An overall rating of potential passenger satisfaction while riding a train

Focus: customer service

Modes: rail

Scope: stop, route, system

System Size: any

Audience: public, decision-makers

Description: This measure rates various aspects of rail vehicles and stations, using trained checkers, to provide a quantitative evaluation of factors that passengers would think of qualitatively.

Factors evaluated by MTA-NYCT for rail vehicles include

1. *Cleanliness and appearance:* amount of litter, car floor and seat cleanliness, presence of graffiti, and window condition;
2. *Customer information:* cars with all system maps correct and legible; cars with all signage correct; and audible, understandable, and accurate public address announcements;
3. *Equipment:* door panel condition, lighting, and climate control; and
4. *Operators:* proper uniforming.

Factors evaluated for rail stations include

1. *Cleanliness and appearance:* amount of litter, station floor and seat cleanliness, and presence of graffiti;
2. *Customer information:* cars with all system maps correct and legible; cars with all signage correct; and audible, understandable, and accurate public address announcements;
3. *Equipment:* stations with functional speakers, escalators/elevators in operation, public telephones in working order, station control areas that have a working booth microphone, trash receptacles usable in stations, token vending machines functional, and turnstiles functional; and
4. *Operators:* proper uniforming and badges properly displayed.

BART evaluates similar factors.

Example target values: For MTA-NYCT in the second quarter of 2001 under Systemwide Subway Car Cleanliness: 46% of the fleet had no litter throughout the day while in service, 43% had light litter, 2% had moderate litter, and 9% had heavy litter. (The subway goal for 2000 was 93% of cars with no litter or light litter.) During the same time period, 98% of cars had no broken door panels.

Major factors: Level of investment in maintenance workers/cleaners, level of investment in equipment and customer information, ridership, level of expectations being created by agency marketing department, amount of competition being faced by a particular mode/system

Data requirements: A statistically valid sample must be established and checkers sent out to collect data for each indicator. Checkers must be sufficiently trained to understand differences between various response categories for each indicator. Customers can also be surveyed to obtain their perceptions regarding the various categories and indicators and to identify and provide weighting for the various factors in the index.

Assessment: Passenger environment indicators can pinpoint problems with specific elements that constitute the subway car or station environment. Periodic customer surveys and focus groups could ensure that the indicators being used to depict the passenger environment actually do represent them. Data collection for the indicators can be costly, as it typically requires an ongoing effort to track changes and quickly react to developing problems and a trained, dedicated checker staff to ensure consistent ratings between checkers and between surveys.

References: MTA-New York City Transit (***52***); Weinstein and Albom (***53***)

◆ Passenger Environment (Bus)

An overall rating of potential passenger satisfaction while riding a bus

Focus: customer service

Modes: bus

Scope: stop, route, system

System Size: any

Audience: public, decision-makers

Description: This measure rates various aspects of buses, using trained checkers, to provide a quantitative evaluation of factors that passengers would think of qualitatively.

Factors evaluated by MTA-NYCT for buses include

1. *Cleanliness and appearance:* amount of litter, exterior dirt conditions, vehicle interior cleanliness, panel condition, presence of graffiti, and window condition;
2. *Customer information:* readable and correct signage; presence of priority seating stickers; correct and legible bus map; correct and adequate bus stop signage; and audible, understandable, and accurate public address announcements;
3. *Equipment:* climate control conditions and operative kneeling feature, wheelchair lift, windows, and rear door; and
4. *Operators:* proper uniforming, proper display of badges, and proper use of kneeling feature.

Example target values: For MTA-NYCT in the second quarter of 2001 under Systemwide Local Bus Cleanliness: 25% of the buses in service at terminals had no litter, 57% had light litter, 6% had moderate litter, and 12% had heavy litter. During the same time, 99% of buses had a readable and correct front sign at 100 feet.

Major factors: Level of investment in maintenance workers/cleaners, level of investment in equipment and customer information, ridership, level of expectations being created by agency marketing department, amount of competition being faced by a particular mode/system

Data requirements: A statistically valid sample must be established and checkers sent to collect data for each indicator. Checkers must be trained to understand differences between each indicator's response categories. Customers can also be surveyed to obtain their perceptions of the various categories and indicators to provide scoring weights for the various factors in the index.

Assessment: Passenger environment indicators can pinpoint problems with specific elements that constitute the on-board environment. Periodic customer surveys and focus groups could ensure that the indicators being used to depict the passenger environment actually do represent them. Data collection for the indicators can be costly, as it typically requires an ongoing effort to track changes and quickly react to developing problems and a trained, dedicated checker staff to ensure consistent ratings between checkers and between surveys.

Reference: MTA-NYCT (***52***)

◆ Percent of Stops with Shelters and Benches

A measure of transit comfort, defined in terms of amenities provided at stops

Focus: customer service

Other Uses: comfort

Modes: bus

Scope: route, system

System Size: any

Audience: public, decision-makers, facility planners

Description: This measure is the number of stops along a given route or within the transit system that have shelters and/or benches. Higher values indicate a greater degree of passenger comfort while waiting for a bus. Rail stations typically provide shelters and benches; thus, this is primarily a measure for fixed-route bus services.

Example target values: All stops with at least 50 daily boarding riders should have a shelter. Some agencies use a point system to determine which bus stops receive benches and shelters. In Austin, approximately 365 bus stops out of 4,000 (9 percent) have one or more shelters. An additional 430 bus stops (20 percent total) have one or more benches.

Major factors: Number of riders using a given stop/station, headway, route directness, weather conditions, passenger characteristics (e.g., age and mobility), maintenance of shelters and benches, placement and orientation of benches and shelters (e.g., visibility and direction of prevailing winds), available space at stops to install shelters or benches, advertising partnering opportunities, access to electricity (for lighting)

Data requirements: Total number of stops, number of stops with shelters and/or benches

Assessment: Measures of comfort such as this are quantified at the “presence” (i.e., are they present?) level. To measure comfort in more detail or by degree is difficult because comfort can quickly become a very subjective measure. This particular measure, however, uses amenities identified as being important to passenger comfort in nearly all the literature, whatever the environment. As a result, this particular measure appears to be a good indicator of basic bus stop comfort for most systems and most riders. Calculation and tracking of this measure is also relatively simple. However, it should be kept in mind that maintenance and other controllable conditions are important influences on passenger comfort.

◆ Customer Satisfaction

An overall rating of customer satisfaction with a transit agency's service

Focus: customer service

Modes: any, assessed by individual mode or as a weighted average (by ridership) of all modes

Scope: stop, route, system

System Size: any

Audience: public, decision-makers

Description: Overall customer satisfaction is measured through market research, by collecting customers' ratings of overall satisfaction with a transit agency's service. Ratings are collected on either a 1-to-5 or 1-to-10 scale. Results can be reported that, for example, 85% of customers rate their satisfaction as at least 4 (on a 5-point scale), or that the average system rating is 4.2.

Example target values: In 1998, 31% of MARTA patrons were "very satisfied" with service and 57 percent were "satisfied." The BCT Transit Customer Satisfaction Index in 1997 was 92.61 and the TALTRAN Index in 1997 was 100.17 (relative to all Florida agencies studied).

Major factors: Customer satisfaction ratings are a measure of the gap between expectations of a service and perception of service performance. Overall satisfaction ratings may be a combination of customers' ratings of service attribute performance. Overall customer satisfaction ratings and gap measures can be affected by less-substantive factors such as the agency's public image or the customers' personal resources, goals, and values. For example, a customer's sensitivity to environmental concerns may impact their overall satisfaction with their experience on public transit.

Data requirements: Market research based on statistically appropriate sampling plans, questionnaire and analysis designs, and data collection methods

Assessment: The measurement of customer overall satisfaction is straightforward, although the data are relatively expensive to collect and present. It often requires the services of professional market research consulting firms. It is less easy to understand the various factors that can impact overall customer satisfaction ratings and to document the specific reasons for changes in overall customer satisfaction ratings. It is important to explore and compare overall satisfaction ratings by customer segments, including mode and route differences and such customer-based factors as frequency of use, availability of a car, or distance from a station or stop.

While passenger environment surveys are typically an ongoing process, customer satisfaction surveys are generally conducted less often (monthly to annually). Thus, there can be a greater lag time between when a customer satisfaction survey is conducted and when a performance measure identifies a problem, compared to passenger environment surveys.

Reference: *TCRP Report 47* (***4***)

Example List of Transit Service Quality Measures

1	Absence of graffiti
2	Absence of offensive odors
3	Accessibility of trains/buses to persons with disabilities
4	Availability of handrails or grab bars on trains/buses
5	Availability of monthly discount passes
6	Availability of schedule information by phone/mail
7	Availability of schedules/maps at stations/stops
8	Availability of seats on train/bus
9	Availability of shelter and benches at stations/stops
10	Cleanliness of interior, seats, windows
11	Cleanliness of stations/stops
12	Cleanliness of train/bus exterior
13	Clear and timely announcements of stops
14	Comfort of seats on train/bus
15	Connecting bus service to stations/main bus stops
16	Cost-effectiveness, affordability, and value
17	Cost of making transfers
18	Displaying of customer service/complaint number
19	Ease of opening doors when getting on/off train/bus
20	Ease of paying fare, purchasing tokens
21	Explanations and announcements of delays
22	Fairness/consistency of fare structure
23	Freedom from nuisance behaviors of other riders
24	Frequency of delays for breakdowns/emergencies
25	Frequency of service on Saturdays/Sundays
26	Frequent service so that wait times are short
27	Friendly, courteous, quick service from personnel
28	Having station/stop near destination
29	Having station/stop near my home
30	Hours of service during weekdays
31	Number of transfer points outside downtown
32	Physical condition of stations/stops
33	Physical condition of vehicles and infrastructure
34	Posted minutes to next train/bus at stations/stops
35	Quietness of the vehicles and system
36	Reliable trains/buses that come on schedule
37	Route/direction information visible on trains/buses
38	Safe and competent drivers/conductors
39	Safety from crime at stations/stops
40	Safety from crime on trains/buses
41	Short wait time for transfers
42	Signs/information in Spanish as well as English
43	Smoothness of ride and stops
44	Station/stop names visible from train/bus
45	Temperature on train/bus--not hot/cold
46	The train/bus traveling at a safe speed
47	Trains/buses that are not overcrowded
48	Transit personnel who know system

SOURCE: *TCRP Report 47* (***4***)

◆ Customer Loyalty

The percentage of “secure” or “vulnerable” transit customers

Focus: customer service

Modes: any, assessed by individual mode or as a weighted average (by ridership) of all modes

Scope: stop, route, system

System Size: any

Audience: public, decision-makers, transit management

Description: Customer loyalty is measured through market research of customers’ ratings of overall satisfaction with a transit agency’s service, likelihood of continued use, and likelihood of recommending the service to others. Customer ratings for each of these three questions are collected on either a 1 to 5 point scale or a 1 to 10 point scale, and are subsequently combined into a 1 to 15 or 1 to 30 overall score. Alternatively, an overall average rating can be developed from a customer’s ratings for each question.

The percent of “secure” customers may be those with a combined customer loyalty score above 10 on a 15-point scale or above 20 on a 30-point scale (or with an average customer loyalty rating above 4 on a combined average 5-point scale or above 8 on a combined average 10-point scale). “Vulnerable” customers are those with loyalty ratings or scores in the bottom third of the rating scale.

Example target values: The MARTA Loyalty Index in 1998 was approximately 77.5. The average CTA Customer Loyalty Indices for all riders in 1995, 1997, and 1999 were 11.7, 12.3, and 12.6 (out of 15), respectively.

Major factors: Customer loyalty measures can identify those riders most likely to leave the system and can target improvement of the service attributes that are the greatest source of their dissatisfaction. However, questions regarding future use of transit and whether a rider will recommend the system to others may be more appropriate and meaningful for choice riders on transit systems. For dependent transit riders with no personal vehicle available, these questions may be less effective in measuring customer loyalty. It has been documented that dependent riders, currently satisfied with transit service, are likely to project that they will not use transit in the future because they are optimistic about their future access to a car for the trips they are making now by transit.

Assessment: The measurement of customer loyalty is straightforward, although the data are relatively expensive to collect and present. It often requires the services of professional market research consulting firms. It is less easy to understand the various factors that can impact customer loyalty ratings and to document the specific reasons for changes in overall customer loyalty. It is important to explore and compare loyalty ratings by customer segments, including mode and route differences and such customer-based factors as frequency of use, availability of a car, or distance from a station or stop.

Reference: Foote, et al. (***16***)

❖ Passenger Load

The number of people on board a transit vehicle

Focus: passenger loading

Other Uses: comfort

Examples: load factor (passengers per seat), area per passenger, number of passengers at the maximum load point, percent/number of trips with standees, maximum number of standees, standing time duration, passenger miles per seat miles

Modes: all

Scope: stop, route, system

System Size: any

Audience: public, decision-makers, service planners

Description: Passenger loading is a significant comfort factor. It also affects the availability of service, when no room is available to board passengers (see *pass-ups*). *Travel time* can be affected when it takes longer to board and alight passengers due to congestion inside the vehicle.

Load factor is a commonly used measure that gives the number of passengers per seat. A value greater than 1.0 indicates that standees are present. The TCQSM First Edition (***2***) uses *gross area per passenger* as its primary passenger loading measure, with approximate load factors given for comparison. (The Second Edition is expected to change to a combination of load factors and *net area per passenger*.) Passenger loading can be measured at any point along a route, but a route's maximum load point should be one of the points measured, as it gives the maximum number of people on board the vehicle. *Number of passengers at the maximum load point* and *maximum number of standees* are both measured there. *Standing time duration* gives the amount of time that passengers must stand. *Percent/number of trips with standees* can be used as a system measure as well as a route measure. Targets can be defined for any of these measures based on service type (e.g., express vs. local), service frequency (higher-frequency services may allow higher loading levels), and/or time of day.

Example target values: LACMTA's load factor target was 1.35, or 15 standees, through June 2000. The March 2001 target was 1.25, or 11 standees. WMATA's load factor targets are 1.0 for all off-peak services, 1.0 for peak express service with a premium fare, 1.1 for peak urban cross-town service, and 1.2 for all other peak services. The maximum number of standees might be 50% of the number of seats (representing the threshold of crush conditions). Commuter rail and long-distance bus services often provide a seat for every passenger, for comfort and/or liability reasons. The TCQSM (First and Second Editions) provides separate LOS thresholds for bus and rail; the general ranges are LOS "A" = passengers need not sit with another, "B" = passengers can choose whom to sit next to, "C" = all passengers can sit, "D" = some passengers must stand, "E" = *maximum schedule load*, "F" = crush loading.

Major factors: Vehicle passenger capacity, vehicle seating configuration, vehicle bunching, time of day, direction of travel, weather, service frequency, special events, policies allowing or prohibiting standees (e.g., standees may not be allowed on high-speed services), configuration of transit vehicle

Data requirements: Passenger counts (either from manual ride checks or APC/AVL equipment) and number of seats provided. *Area per passenger* also requires knowledge of vehicle dimensions; *standing time duration* requires time information.

Assessment: These measures are simple to calculate, once the maximum load point is known, and are readily understood by the public, but require extensive data collection. Other measures that use passenger count data include measures of *seat capacity* and *ridership*.

◆ Feature Existence

Measures of how much of certain features, amenities, or infrastructure are provided

Focus: comfort

Other Uses: customer service, goal accomplishment

Modes: all

Scope: stop, route, system

System Size: any

Audience: public, decision-makers, transit management

Description: This is a measure of whether something (e.g., a telephone information line) exists, or how much of something (e.g., percent of buses with non-skid floors). The former has two values, yes or no. Either type of measure can be used in summary tables comparing various aspects of different services or systems.

Example target values: The percent of subway cars with present, legible, and correct signage for MTA-NYCT in the quarter ending June 2001 was 96%. The percentage of MTA-NYCT subway station phones that are fully operational was 95% in the quarter ending June 2001.

Major factors: Varies depending upon the feature being measured.

Data requirements: Records of the feature being measured.

Assessment: This measure is useful for peer comparisons between systems and for evaluations of service equity within a particular system.

◆ Action Achieved

Measure of success in implementing short-term, planned projects

Focus: goal accomplishment

Modes: all

Scope: system

System Size: any

Audience: public, decision-makers, transit management

Description: This is a measure of whether a particular short-term project or action that was promised or planned was actually completed. It is typically expressed in annual reports using such phrases as: "the Central Transit Center opened on schedule" or "a customer complaint line was established." Once the action has been achieved, the measure no longer needs to be tracked for that particular action.

Example target values: From Denver RTD's Performance Goal 7 ("to meet the future transportation needs of the District"):

- "Award contract for Southeast Corridor design/build package" (goal of receiving proposals in the first quarter of 2001; proposals were received as scheduled)
- "Hold three Local Government Planning workshops by December 31, 2001" (first workshop held January 4, 2001; second workshop held March 29, 2001)

Major factors: Ability to complete planned projects on schedule

Data requirements: List of planned projects, with their scheduled and actual completion dates

Assessment: Although not generally treated as a performance measure in the literature, *action achieved* is a measure that transit agencies use frequently to report their success in implementing new programs over the past year. *Percent of goal achieved* is more appropriately used to report progress on multiple-year (or other time period) or multiple-unit (e.g., replacing eight buses) projects.

◆ Percent of Goal Achieved

Measure of success in implementing longer-term planned projects

Focus: goal accomplishment

Modes: all

Scope: system

System Size: any

Audience: public, decision-makers, transit management

Description: This is a measure of whether longer-term projects are progressing as originally intended. It is typically expressed in annual reports using such phrases as “75% of operators have received customer dispute training” or “six of the eight buses without wheelchair lifts have now been replaced.” Once the project has been completed, the measure no longer needs to be tracked for that particular project.

Example target values: From Denver RTD’s Performance Goal 7 (“to meet the future transportation needs of the District”):

- “Acquire right-of-way needed for Southeast Corridor” (goal of 20% in the first quarter of 2001; 20% achieved)
- “Thornton park-and-ride expansion” (goal of 50% of design completed in the first quarter of 2001; 15% achieved)
- “Perform transit-oriented development station profiles” (goal of six for 2001; one completed in the first quarter of 2001)

Major factors: Ability to complete planned projects on schedule

Data requirements: List of planned projects, with their scheduled and actual completion dates and number of people or items affected

Assessment: Although not generally treated as a performance measure in the literature, *percent of goal achieved* is a measure that transit agencies use frequently to report their success in implementing various programs over the past year. *Action achieved* is an alternative measure that can be used for short-term projects and projects that have no range between being 0% completed and 100% completed.

COMMUNITY MEASURES

Community measures assess transit's role in meeting broad community objectives. Three main sub-categories of community measures are identified:

1. *Mobility*—the ease of traveling between locations within a community;
2. *Outcomes*—the impact of transit service on different aspects of a community; and
3. *Environment*—assessing the relationship between transit and the environment.

The following measures presented under other categories in this document also relate to community goals and objectives:

- Route (corridor) spacing,
- Service coverage,
- Service hours,
- Fleet composition,
- Service denials,
- On-time performance (fixed-route),
- On-time performance (demand-responsive),
- Passenger safety, and
- Energy consumption.

The following references provided a number of community measures that are described throughout this section: Federal Transit Administration (***54***), Forkenbrock and Weisbrod (***55***), and McDonald Transit Associates, Inc. (***56***).

❖ Mobility

The degree of ease of travel between origins and destinations

Focus:	mobility
Other Uses:	availability, travel time
Examples:	Origin-destination travel times, average speed or travel time, vehicle-miles traveled (VMT) by congestion level, lost time or delay due to congestion (e.g., actual travel rates in minutes per mile minus acceptable travel rate in minutes per mile), relative delay rate (i.e., delay rate divided by acceptable travel rate), delay ratio (i.e., delay rate divided by actual travel rate), roadway level of service or v/c ratios, corridor mobility index, travel rate index, reliability factor, congestion burden index, transportation choice ratio
Modes:	all
Scope:	stop, route, system, region
System Size:	any
Audience:	public, decision-makers, operations staff, MPOs/planners

Description: *Mobility* and *accessibility* are closely related and it is often difficult to distinguish between the two types of measures. For purposes of this summary, *mobility* measures have been classified as those that focus more on travel times between origins and destinations, while *accessibility* measures focus more on the number of origins and destinations that can be reached.

Meyer and Miller describe a number of potential measures. *Total delay* in vehicle-minutes is (actual travel time minus acceptable travel time) multiplied by vehicle volume. *Congested travel* in person-miles is the sum of all congested roadway segment lengths in miles, multiplied by person volume. The *corridor mobility index* is (facility volume [persons] multiplied by average travel speed [mph]), divided by an optimum facility value (person-mph), typically 125,000 for freeways and 25,000 for streets. The *travel rate index* is (freeway travel speed divided by freeway free-flow speed multiplied by peak-period freeway VMT) multiplied by (street travel speed divided by street free-flow speed multiplied by peak-period street VMT) divided by (peak-period freeway VMT plus peak-period street VMT). The *reliability factor* is the percent of time that a person's travel time is no more than 10% higher than average.

For transit, specifically, a comparison between the mobility of those who drive and those who take transit can be useful. For example, average transit travel times by transit for a certain set of origins and destinations could be divided by the average auto travel times to create a mobility index for transit customers. Alternatively, the transit times could be expressed as a percentage or difference of auto times.

The Surface Transportation Policy Project (STPP) has developed two measures to quantify the effect of transportation options on congestion levels. The first measure, the *Congestion Burden Index*, is the product of the Texas Transportation Institute's *Travel Rate Index* and the percentage of the work force driving to work. The second measure, the *Transportation Choice Ratio*, is the ratio of hourly miles of transit service to the total lane miles of interstates, freeways, expressways, and principal arterials.

Example target values: VIA reports that congestion would increase by 4.6% without transit service. Vehicle-miles of travel would be increased by 117 million without transit service.

Major factors: Capacity, volume-to-capacity ratio, congestion levels, signal control, fleet management, ITS/APTS/ATIS deployment, accessibility

Data requirements: To collect *travel time, speed,* and *VMT* data by origin and destination, it is necessary to conduct surveys, such as O-D surveys, home interview surveys, roadside interviews, or postcard surveys. It is also possible to obtain the data directly by using test vehicles during different times of the day. Traffic volume data and estimates of capacity (e.g., using the *Highway Capacity Manual*) are required to calculate v/c ratios. *Speed* data for links are required to determine delay and congestion.

The *Congestion Burden Index* requires the percentage of work force driving to work (from Census data), and travel time/speed studies, free-flow rates or acceptable-flow rates, and vehicle-miles traveled or person-miles traveled for freeways and arterial streets. The Transportation Choice Ratio requires data on hourly miles of transit service, which can be generated from NTD data by dividing annual vehicle revenue miles by annual vehicle revenue hours, and information on the number of lane-miles of interstates, freeways, expressways, and principal arterials within the study area (from the Federal Highway Administration).

Any type of interview would be costly. Mail-in postcard surveys may be the least expensive of the survey instruments. Telephone interviews would probably be moderately expensive—less costly than mail-in surveys, but more costly than face-to-face interviews.

The amount of data gathered must be sufficient to achieve an acceptable confidence level and margin of error. Typically, a 90% or 95% confidence level and a 5% or 10% margin of error are targeted. In addition, a valid sampling plan should be established (e.g., random, stratified, cluster, etc.) Data analysis will require vigilance in terms of accurate data input and consistent analytical procedures from period to period. Otherwise, trends and period-to-period comparisons may be jeopardized.

If ITS/APTS technologies have been deployed, it may be possible to collect the entire set of data with a high level of accuracy.

Assessment: Mobility is a fundamental concern of communities and their residents. Most MPOs list mobility as one of their goals. There is no question that mobility has a direct bearing on quality of life, since the ease with which one can reach specific activities determines whether or not one will engage in them. Which definition or measure of mobility would be appropriate for a particular community depends on the values and needs of its residents. Therefore, public outreach and involvement in community goal-setting would be recommended. Note that the appropriateness of a measure and its definition depend on user characteristics (e.g., demographics) and trip characteristics (e.g., trip purpose), and the modal preferences of area residents.

The *Congestion Burden Index* is limited in situations where transportation alternatives may be available but commuters choose not to use them. In that regard, the index does not represent the available capacity of alternative modes. In addition, converting automobile trips to transit trips, for example, could induce additional automobile trips just as constructing additional lane-miles of roadway could.

References: Meyer and Miller (***57***), Surface Transportation Policy Project (***58***), Surface Transportation Policy Project and Center for Neighborhood Technology (***59***), VIA Metropolitan Transit (***60***)

❖ Trip Generation

Changes in trip making as a result of transit service being available

Focus: mobility

Other Uses: capacity

Examples: number of automobile trips eliminated, change in automobile vehicle-miles traveled, number of trips not made in absence of transit, percent of trips made by transit

Modes: all

Scope: corridor, system, region

System Size: any

Audience: public, decision-makers, MPOs/planners, transportation engineers

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Description: These measures look at (1) transit's role in reducing automobile trips, (2) the reduction in mobility that results when people are unable to travel due to a lack of transportation options, and (3) the percentage of people who choose to use transit when it is available as a viable option. These measures are often used to help justify transit as an alternative to widening a roadway facility (or for postponing roadway improvements).

The *number of automobile trips eliminated* uses unlinked (i.e., origin-to-destination trips, rather than boardings) transit ridership—particularly among choice riders—to determine how many additional automobile trips would have been made had those persons decided to drive. With data from regional transportation models and information about where choice riders live and work, an estimate can be made of how many additional vehicle-miles would have been traveled had these riders driven. This measure, along with the *change in vehicle-miles traveled,* is often evaluated on a corridor basis, in conjunction with new or expanded transit service.

Transit's ability to provide mobility to those who do not have access to a private automobile can be measured by the *number of trips not made in the absence of transit*; this measure requires survey information.

Finally, traditional *mode splits* (the number of trips made by transit divided by total trips made by all modes) tend to understate the number of people who use transit when it is available as a choice. Using only those areas with service, and factoring in the amount of time that service is provided, the number of people choosing transit has been found to be considerably higher than the 1-2% mode split often used. The adjusted mode split is calculated as the number of trips made by transit divided by the total trips made by all modes in the areas served by transit (and, optionally, made during the times when transit service was provided). For more information, see the comments under *Transit Service Accessibility Index*.

Major factors: Number of choice riders, average trip lengths (particularly commute trips), service coverage, hours of service

Data requirements: Survey or census data are required to calculate the number of people who own an automobile (i.e., are potential choice riders), the amount of transit usage by these people, and their average commute trip lengths. Surveys of captive riders are required to determine how many of the trips could not be made if transit service were not available. Adjusted mode splits can be calculated using automobile trip data from a regional planning model, transit ridership information, service coverage, and hours of service data. A corridor analysis may be required to assess the *number of automobile trips eliminated* and the *change in automobile vehicle-miles traveled*.

Assessment: The *number of automobile trips eliminated* is a commonly used measure to describe transit's role in reducing automobile pollution and congestion and avoiding or postponing the need for roadway improvements. Some argue that quantifying this benefit may be difficult, as the trips saved by people using transit may be taken up by latent demand for other automobile trips. However, the same argument could be made about highway capacity improvements, that is, that providing more capacity may induce trips that otherwise would not have been made.

Change in vehicle-miles traveled measures the ability of transit to either eliminate auto trips completely or to shorten them (e.g., by diverting drivers to a park-and-ride lot). The same issues that apply to *number of automobile trips eliminated* apply to this measure.

The *number of trips not made in absence of transit* is a measure of the reduction in overall trips that occurs when people have limited access to a travel mode.

Percent of trips made by transit can be measured three ways: overall, using the traditional mode split, which generally does not favor transit outside the largest cities; areas served by transit, comparing trip-making patterns in areas where riding transit is available as an option; and areas served by transit at times service is provided, introducing a temporal component to determine when transit is an option. Both the *Florida Transit Level of Service Indicator* and the *Transit Service Accessibility Index* can be used to calculate adjusted mode splits in areas served by transit, and in areas served by transit at the times service is provided.

References: FDOT Public Transit Office (***40***); Navari (***44***) (mode splits)

❖ Demographics

The number of people for whom transit could be a significant travel mode

Focus: mobility

Other Uses: availability, ADA accessibility, paratransit

Examples: percent of households in service area without cars, percent of population in service area too young to drive, percent of population in service area with incomes under $X, percent of elderly/disabled population in service area

Modes: all

Scope: sub-area, system, region

System Size: any

Audience: decision-makers, MPOs/planners

Description: Measures in this family look at the number of people within an area who may not own an automobile and would therefore be likely to rely on transit service.

Example target values: Capital Metro pays “close attention” to areas where (1) the percentage of households without an automobile exceeds 10 percent and (2) the percentage of elderly residents exceeds 10 percent. Currently, five areas in Austin meet the first criterion and three meet the second criterion.

Major factors: Family size, income, age

Data requirements: Demographic information for given areas can be determined from census data; the areas that fall within an agency’s service area will also need to be determined.

Assessment: These measures are useful indicators of the ridership potential of certain kinds of potential transit users. They use census data that are relatively easy to obtain and work with. Using these measures should not imply that these are the *only* kinds of customers that transit serves; other community measures can be used to reflect transit benefits for choice riders and non-riders. Other types of areas (e.g., neighborhoods) can be substituted for “service area” in these measures.

❖ Accessibility

The ease and convenience with which desired destinations can be reached

Focus: mobility

Other Uses: availability, ADA accessibility

Examples: number/percent of people/jobs served by transit, percent of population living within X miles, Y minutes, Z dollars, or N transfers of opportunities (e.g., jobs, shopping) via transit; percentage of major activity centers (office complexes, hospitals, schools, etc.) within X miles or Y minutes of transit services or facilities; number of transportation options available; transit vs. auto accessibility; percent of special-needs populations with access to transit services

Modes: all

Scope: stop, route, system, region

System Size: any

Audience: public, decision-makers, operations staff, MPOs/planners

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Description: Meyer and Miller state that "people and activities will choose among locations based on a location's attractiveness for a particular type and scale of activity and on the location's accessibility to other activities." Accessibility can be measured with either a population focus or an activity center focus. The former represents the portion of the residents able to reach specific destinations by transit, while the latter represents the portion of the destinations that may be accessed by transit. The measure can be separated by urban and rural areas. *Welfare-to-work accessibility* has its own set of specialized measures and is treated separately.

Example target values: Capital Metro tries to provide fixed-route service to major activity centers. Major activity centers include employment centers with at least 500 employees, hospitals or nursing homes with at least 100 beds, social service agencies with at least 75 daily clients, educational institutions with at least 1,000 students, retail centers of at least 100,000 square feet, government agencies with at least 100 daily clients, and apartment complexes of at least 300 units. Currently, approximately 109,000 employees of major Austin employers have transit service; approximately 32,500 do not. San Antonio's VIA cites European studies that quantify a "barrier effect" resulting from very wide roadways; a study in Norway estimates that the cost of the barrier effect is $112 per capita. Transit is recognized as a means to reduce this effect.

Major factors: Degree of mobility, degree of directness for getting to and from the system, transit fares, availability of parking facilities for those who park and ride, ease of walk access to and from transit, agency resource constraints, effective planning and route design, population density/dispersion patterns, frequency, span of service, zoning that places higher residential densities closer to transit service

Data requirements: Most of the data requirements mentioned for *mobility* apply to accessibility as well, and are not duplicated here. Using basic GIS software, the percent of population living within X air miles (as the crow flies) of transit stops (or percent of jobs within X air miles of transit stops) may be easily calculated. Similar calculations involving actual walking paths or walking times generally require more advanced GIS software and some knowledge of the pedestrian environment. There are three levels of analysis: (1) binary: the transit system is accessible to a certain group of individuals; (2) maximum impact option (continuous measure): actual values of travel times can be compared; and (3) weighted values: assigning a relative importance to different kinds of employment centers, for use with a gravity model in evaluating different destinations and alternatives. Population data may be available from census data or the regional transportation model; job data may be available from state or local labor departments or the regional model. Specialized software, such as a regional model, advanced GIS software, or Florida's

TLOS software will be required to perform network calculations of the number of people living within a certain time or number of transfers of a location. Local development and building permits can be used to determine the number of housing units developed near transit.

Assessment: Accessing some opportunities may be possible only by auto. As a result, the measure of accessibility by transit is particularly important for those who are transit dependent. However, it is also important for auto users when their car is being repaired and during severe weather and other situations when auto users may not want to drive.

The measure in the definition is areawide accessibility. Local accessibility depends on the degree of directness for getting to the destination, knowledge of where and how to go, the simplicity of finding it, the availability of parking facilities, and the ease of walking to its entrance.

In urban areas, due to high levels of congestion, the temporal criteria and number of transfers may be more appropriate than distance criteria.

The *number of transportation options* available to a resident also may be useful in assessing accessibility. For transit, these kinds of questions can be asked: Is transit an option? How many different routes are accessible? How many different modes are accessible? Measures of transit supply, such as bus route miles, rail track miles, or route/line spacing, may not be suitable, since they do not indicate whether transit riders reside or work near the system. However, density measures such as route miles per capita or track miles per capita may provide some information about accessibility.

A measure that compares *transit vs. auto accessibility* would be the average travel time for transit divided by the average travel time for auto, for various origin-destination pairs. If the proportion of transit users is high and this ratio is also high, it indicates that more resources need to be invested in transit.

In the literature, the measure of *average travel time* is suggested; however, it would not be a good measure, because some origins may not contain a high number of transit riders.

The typical formula often used for planning purposes to calculate accessibility is as follows:

$$A_i = \sum_{j=1}^{n} F_j^{\alpha} e^{-\beta t_{ij}}$$

where

A_i = accessibility of zone *i* to, for instance, shopping opportunities
F_j = amount of retail floor space in zone *j*
t_{ij} = travel time from zone *i* to zone *j*
n = number of zones with retail stores
α = parameter indicating the relative sensitivity of accessibility to store size ($\alpha \geq 1$)
β = parameter indicating the sensitivity of trip making to travel time (i.e., the larger β is in magnitude, the less likely people are to travel long distances to shop)

References: Meyer and Miller (***57***), VIA Metropolitan Transit (***60***)

❖ Welfare-to-Work Accessibility

The relative ease with which desired destinations of welfare-to-work clients can be reached

Focus: mobility

Other Uses: availability

Examples: welfare-to-work accessibility index, percent of TANF clients within X miles/Y minutes/Z dollars/N transfers of daycare, percent of TANF clients able to access welfare-to-work transportation programs, percent of entry-level jobs with transit service during work hours, percent of daycare centers with transit service during business hours

Modes: all

Scope: stop, route, system, region

System Size: any

Audience: public, decision-makers, operations staff, MPOs/planners

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Description: These measures evaluate the ability of the transit network to meet the job-related transportation needs of TANF (temporary assistance for needy families) clients. Job-related transportation needs revolve around transportation from clients' residences to entry-level jobs. In addition, many clients need to stop at daycare centers to drop off and pick up children.

Thakuriah and Metaxatos suggest an *accessibility index* that includes a weighted combination of transit and auto travel times of TANF clients to jobs, and the competition among TANF clients for jobs. This latter factor is used because excessive competition would make it difficult for clients to obtain a job. For instance, there may be some entry-level jobs in the CBD, but if the competition for the jobs is extremely high because TANF clients live in surrounding neighborhoods, the likelihood that the client will get one of those jobs declines.

Example target values: 100 percent of all entry level jobs in the Chicago metropolitan area are accessible within 90 minutes by car; the percentage drops to 60 percent for travel by public transportation.

Major factors: Agency resource constraints, effective planning and route design (proximity to clients, daycare centers, entry-level jobs), population density/dispersion patterns, level of service (e.g., frequency), travel time, span of service

Data requirements: A TANF client database must be obtained from a state or local human services agency to pinpoint the residences of the clients. To obtain information about entry-level jobs, it is necessary to use data from a state or local labor department, the MPO, or the Public Use Microdata Sample from the Census Bureau.

The locations of clients, jobs, and daycare centers can be plotted using GIS, based on addresses. Using a spatial interaction model, expected origin-destination flows may be estimated, and transit travel times can be calculated.

Assessment: The reliability of the TANF client database and data sources for entry-level jobs and daycare centers will affect the accuracy of the measure. A supplemental measure might be percent of the transit-dependent population served by transit, since many TANF clients are transit-dependent. Cost and travel time to daycare might be included in the accessibility index.

Reference: Thakuriah and Metaxatos (***61***)

◆ Service Equity

The distribution of transit benefits and impacts on various communities and population groups

Focus: mobility

Other Uses: availability

Modes: all

Scope: stop, route, system, region

System Size: any

Audience: public, decision-makers, transit managers, MPOs/planners

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Description: Equitable distribution of costs and benefits resulting from transit projects or services can be measured by examining those who benefit from the project or service and those who are worse off. An evaluation can also focus specifically on whether minority and/or low-income communities are better or worse off. Although the effects might be measured in terms of net benefits (e.g., *X dollars per resident*) for a study area, it is better to examine each effect separately within different portions of the study area. The special concerns of low-income and minority communities should be incorporated in the calculation of the net benefit.

Major factors: The distribution of transit project or service impacts—economic development, noise, community cohesion, visual quality, property values—among various population groups will affect this measure. For example, jobs within 60 minutes of transit access by low-income population can be compared with jobs within 60 minutes of transit access by the rest of the population. The transportation disadvantaged (those without access to a car) can be considered another special population group. A measure for that group might be the percentage of transportation disadvantaged having access to transit services versus the percent of the non-transportation disadvantaged population having access to transit.

Data requirements: GIS can be used to create maps showing relevant data and areas affected. The indicators used to measure the various social and economic and environmental effects of transit can be mapped along with the locations of special population groups. By doing this, it is possible to compare the effects on special populations with those in the entire impact area.

To identify transportation disadvantaged populations, the following indicators are suggested: households with no autos, population with physical disabilities, low-income single parents, people too young or old to drive, unemployed adults, and recent immigrants. Data sources include labor statistics, census, NPTS, consumer surveys, and social service agencies. Other methods that may be used to gather necessary data are travel demand modeling, focus groups, interviews, travel diaries, and case studies.

Note that (1) negative effects may be concentrated, while positive effects can be quite dispersed throughout a community, and (2) a decrease in mobility of, for example, low-income population (that already has low mobility) has a greater effect than for higher-income population who start off with higher levels of mobility. Hence, a micro-level analysis is recommended.

Assessment: The issue of equitable distribution of impacts (both benefits and disbenefits) of transit services is an important one. For a transportation disadvantaged individual, the elimination of one bus stop can make a significant difference in that person's quality of life. However, calculating distribution effects can be costly since it requires substantial data and analysis for each effect. Also, it may not be possible to pinpoint all effects of transit service and transit projects on the various special population groups. The difficulty of converting the effects into dollars may be an issue. Furthermore, to try to determine overall equity would be extremely difficult, as each impact has different implications and effects on each of the various special population groups. In the case of community measures, aggregating (for instance), mobility and visual quality measures may cancel out the impacts on various population groups.

Mobility for a certain group of residents may be high, while visual quality may be low. Trying to aggregate the two would cause the effects to cancel each other, diminishing the benefits of the measures. Because the issue of equity is included in the other community measures, the need for a separate measure of distribution effects may be questionable.

❖ Community Cohesion

The patterns of social networking within a community

Focus: mobility

Examples: surveyed level of community cohesion, transit route distance versus air distance between neighborhoods and activity centers

Modes: all

Scope: sub-area, system, region

System Size: any

Audience: decision-makers, route planners, transportation engineers, capital projects staff, MPOs/transportation planners

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Description: Transit projects may have both positive and negative effects on community cohesion. In general, the net benefits will be positive, in terms of increased connectivity and cohesion of residents (e.g., as a result of a new rail line). However, the particular neighborhood that the rail line runs through may have a net negative benefit. Further, the net negative effects of highway or road construction in the neighborhood are apt to be worse.

Community cohesion is difficult to quantify, so qualitative methods are often used to assess a transit project's impact on it. However, *transit route distance vs. air distance between neighborhoods and activity centers* can be used as a quantitative way to assess the barrier effect of highways, railroads, canals, and other manmade and natural features, assuming a reasonable standard exists for *route directness*.

Example target values: VIA estimates that 19% of the San Antonio population has used VIA's special event service at least once.

Major factors: Direct effects of household and business relocation caused by transit projects and construction; direct effects of structural (physical) barriers; changes in noise, pedestrian safety, property values, and visual quality; indirect effects of psychological barriers

Data requirements: Information (community characteristics, social institutions) should be collected from community leaders and civic groups, and researchers should spend time in the study area to estimate levels of community cohesion via workshops and interviews. Surveys might be conducted using a scale with the following possible range: very low (cohesion), low, average, high, very high. A numerical scale (e.g., 1-10) might also be used. Comparative transit and air distances can be calculated by hand from a map, for individual neighborhoods, or can be more easily calculated using GIS software.

Assessment: Small changes in community cohesion due to changes in transit services may be difficult to track. The exact contribution of transit to the level of cohesion may be difficult to ascertain.

Reference: VIA Metropolitan Transit (***60***)

❖ Community Economic Impact

Extent that transit services contribute to a community's productivity, economic growth, and competitiveness

Focus: outcomes

Other Uses: economics

Examples: percent of state/regional gross product represented by transit, economic costs of pollution caused/alleviated by transit, public expenditures by mode, tax revenues to state and local government due to transit, amount lost annually to vehicle accidents in the absence of transit, cost of constructing additional highway capacity in the absence of transit, cost of constructing additional parking spaces in the absence of transit

Modes: all

Scope: system, region

System Size: any

Audience: public, decision-makers, MPOs/transportation planners

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Description: Economic development is characterized by increasing incomes, job choices, activity choices, stability of jobs and income, amenities, and fiscal impacts (e.g., increased tax base). Community economic development impact measures assess the direct fiscal impacts of transit on a community. Transit may also have an indirect economic impact, such as increased incomes and tax revenue resulting from more people being able to travel to jobs and from development of lands that would otherwise be used for highway infrastructure and parking.

Example target values: A 1994 study in Indiana found that total annual retail sales associated with transit riders was $104 million. The study estimated that for every $1.00 invested in transit, the return is $1.38 (based on an economic input-output model). Expenditures associated with VIA capital improvements and operations were projected to add $82 million per year to the Bexar County economy between 1997 and 2001. An economic model developed by VIA indicated that, when these expenditures were compared to funds collected from the public through fares and taxes, VIA had "a significant net positive effect on the regional economy." The model also indicated that, over the past 25 years, VIA's contributions to economic growth have resulted in approximately 3,600 jobs. VIA estimates that it would cost up to $363 million to build enough roadway lane-miles to accommodate VIA's ridership. VIA cites a study claiming that, for every dollar invested in low-cost transportation, the cost of programs like Medicare and Unemployment Compensation is reduced by $0.60.

Major factors: Transit agency size, traffic congestion, use of alternative fuels in transit vehicles, public funding priorities

Data requirements: The number of direct jobs in the transit industry in the area may be obtained directly from each transit agency. MPOs will have data on estimated roadway construction project costs. Tax revenue that is dedicated to transit can be determined from state or local taxing authorities. The economic costs of pollution, accidents, and congestion may be difficult to determine since valuing each impact is often problematic.

Assessment: Measures based on either tax revenue or agency employment and payroll data will be relatively easy to calculate and hard to dispute. The other measures involve some degree of judgment or estimation, and they are therefore harder to calculate and the results less certain and easier to challenge. Ideal measures listed in the FTA report include net worth to society of access afforded by transit services, change in economic output and productivity as a direct result of improvement in transit services, and the ability to substitute transit for other factors of production. Desired measures include change in output per dollar investment in transit service, percent of businesses indicating an increase in employment or wage levels attributable to cost or productivity improvements in transportation service, and percent or number of firms citing access and mobility as primary factors in location and profitability.

References: Federal Transit Administration (***54***), McDonald Transit Associates, Inc. (***56***), VIA Metropolitan Transit (***60***)

❖ Personal Economic Impact

Extent that transit services contribute to an individual's financial well-being

Focus: outcomes

Other Uses: economics

Examples: percent of household income used for transit, difference in transit and automobile out-of-pocket costs, average fare, average system user cost per trip, TransitChek program participation

Modes: all

Scope: system, region

System Size: any

Audience: public, decision-makers, MPOs/transportation planners

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Description: Personal economic impact measures assess both the amount of money people spend for mobility, as well as the individual out-of-pocket cost savings that individuals derive from choosing to use transit instead of driving. *TransitChek program participation* is the percentage of area employees whose employers participate in a transit subsidy program such as TransitChek.

Example target value: A 1994 study in Indiana found that, without transit, personal expenditures on transportation would increase by $18.2 million annually. VIA's economic model indicates that VIA's operations and capital expenditures create over $53 million in personal income annually.

Major factors: Average income, fares, parking costs, tolls, costs of fuel, insurance, registration, routine maintenance, and depreciation for automobiles

Data requirements: Average incomes and average number of trips taken by mode can be obtained from census data. Other data requirements include average parking costs by area, transit fare information, roadway toll information, and a per-mile or equivalent cost of operating an automobile that accounts for various cost factors. Travel demand models are another potential source for much of this information.

Assessment: *Percent of household income used for transit* can be used in comparison with other measures (e.g., percent of income used for housing, food, etc.) to see how much of a household's budget is required to satisfy basic mobility requirements. The *difference in transit and automobile out-of-pocket costs* reflects the daily, monthly, or annual savings that transit users achieve by taking transit in cities that have high parking costs or major toll facilities. In areas with low- or no-cost parking, it can provide a starting point for determining an appropriate employer transit subsidy level to offset the benefit of free parking. Other factors, such as the value of travel time, might also need to be considered. Although the total costs of owning an automobile are typically far greater than the out-of-pocket costs (e.g., registration, insurance, service, maintenance, etc.), these costs are spread out over a greater variety of trips, and thus are less likely to be perceived by individuals as an out-of-pocket cost. *Average system user cost per trip* can be used to measure the actual difference in costs between modes, including factors not typically perceived by individuals. *Average fare* is a useful factor to help determine appropriate peer agencies for comparisons. *TransitChek program participation* can be used to determine the number of area employees who can use transit for a lower monthly cost, due to the provision of an employer transit subsidy.

References: McDonald Transit Associates, Inc. (***56***), VIA Metropolitan Transit (***60***)

❖ Efficiency

The financial return on the community's investment in transit

Focus: outcomes

Other Uses: economics

Examples: local and state transit funding per capita, return on transit investments, percent of reverse commute trips made by transit, percent of private-sector contribution to transit construction/renovation project, percentage of revenue from business activities

Modes: all

Scope: corridor, system, region

System Size: any

Audience: public, decision-makers, financial staff, MPOs/transportation planners

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Description: Measures in this family assess the financial return on the community's investment in transit, the amount of the community's investment, and how efficiently transit agencies are able to work with this investment. Some of these measures could also easily fall into the "economic" category, but they are included here because they are tied to community goals or funding requirements, or because they are often used in peer comparisons. *Percent of reverse commute trips made by transit* is the number of transit trips made in the off-peak direction (particularly along particular corridors), divided by the total number of trips (auto plus transit) made in the off-peak direction. Revenue from business activities can include advertising revenue, lease revenue, and any other form of revenue not derived from either fares or government subsidies. *Return on transit investments* looks at how much additional revenue was derived from a particular investment in transit services or facilities.

Example target values: Implementation of a fare-free transit zone in downtown Albany, New York, in 1978 tripled downtown ridership and increased accessibility within the CBD. The fare-free transit zone had positive impacts on sales among downtown merchants, particularly during the quarter covering the holiday season. Merchants in close proximity to major bus routes seemed to have benefited more than merchants farther away.

Major factors: Local support for transit, availability of private-sector partners for projects, restrictions on kinds of business activities a transit agency can undertake, high reverse commute travel demands

Data requirements: Agency financial data relating to government subsidies, fare revenue, and revenue from business activities; transit project cost allocations; transit ridership and roadway traffic volume data in corridors

Assessment: *Percent of reverse commute trips made by transit* measures how efficiently vehicles that are already required for peak-direction service can be utilized in the off-peak direction. The *percentage of revenue from business activities* measures how well an agency can supplement fare and tax revenue with revenue from other sources, to minimize public subsidies, or to minimize passenger costs. *Local and state transit funding per capita* is useful for identifying peer systems.

❖ Communications

How well transit agencies are able to communicate with their communities

Focus: outcomes

Other Uses: economics, availability

Examples: number of residents with positive transit perceptions in community survey, number of residents with knowledge of transit service availability within their community, information provision for persons with disabilities, information provision for passengers for whom English is not their primary language

Modes: all

Scope: corridor, system, region

System Size: any

Audience: public, decision-makers, marketing staff

Description: These measures address how successfully transit agencies are able to communicate with the citizens of their community. Not all of these citizens will be regular transit users, but they may vote on transit funding issues or have friends or family members who use transit service. A lack of information, because it is not provided, or because of a language or disability barrier, can also serve as an access issue. If someone does not know how, when, or where to use transit service, it is very hard for them to become a user. *Information provision for persons with disabilities* can be measured, for example, by the percentage of brochures available in large-print or Braille formats. *Information provision for persons for whom English is not their primary language* can be measured by the number of languages spoken by customer-service agents or by the number of languages in which "how-to-ride" material is provided.

Major factors: Success of marketing and communications efforts, agency responsiveness to community goals and concerns, number of languages spoken by significant numbers of local residents

Data requirements: Surveys are required to measure community transit perceptions and knowledge of transit service availability. Data required for other measures could include a count of the number of brochures available in alternative formats or languages and an employee skills database that includes information on the languages spoken fluently by each employee.

Assessment: The *number of residents with positive transit perceptions in a community survey* can serve as an indicator of the success of an agency's "image" marketing efforts, as well as an indicator of whether an agency should work to improve its community image before presenting a transit funding package to voters. It also works well as an overall indicator of the success of an agency's efforts and is suitable for tracking on an annual basis. The *number of residents with knowledge of transit service availability within their community* serves as an indicator of how successful an agency's "information" marketing efforts are. The information provision measures are useful for evaluating the breadth of potential customers who have ready access to transit information.

❖ Employment Impact

Use of transit by employable persons to commute to work

Focus:	outcomes
Other Uses:	community economic impact
Examples:	direct jobs created/supported by transit, indirect jobs created/supported by transit, percent of employable persons who are working and using transit to commute to work, percent of TANF clients using welfare-to-work transportation whose job tenure is at least X years, percent of region's unemployed/low-income residents citing transportation access as a principal barrier to seeking employment
Modes:	all
Scope:	system, region
System Size:	any
Audience:	public, decision-makers, operations staff, MPOs/transportation planners

Description: A good transit network helps transport workers, including the transportation disadvantaged, to their jobs, and assists persons in welfare-to-work programs find and keep jobs.

Example target values: A 1994 study in Indiana found that there were 2,600 people employed directly in the transit industry. This number increased to 4,300 people if those employed indirectly were included. VIA reports that 35 percent of bus commuters state they could not travel to work without the transit system.

Major factors: Accessibility of transit services, mobility, educational background, work experience. For welfare-to-work clients, other factors are the number of entry-level jobs within a given travel time "catchment area" for which it is cost-effective for a client to travel at the wage rate that he or she will receive, and the number of other clients competing for those jobs in the catchment area.

Data requirements: In order to identify welfare-to-work clients, it is necessary to access the databases of state or local departments of human services. Entry-level job openings could be estimated by data from state or local departments of labor, the MPO, or the Public Use Microdata Sample from the Census Bureau.

Assessment: Transit contributes to employment rates, especially for welfare-to-work clients. However, the reverse is also true: employment rates contribute to transit. As a result, it is very difficult to assess the impact of transit on employment rates.

References: McDonald Transit Associates, Inc. (***56***), VIA Metropolitan Transit (***60***)

❖ Property Value Impact

Effect of transit services and facilities on nearby property values

Focus: outcomes

Examples: difference in property values of property adjacent to transit routes and facilities vs. property values elsewhere, difference in lease/rental rates for property adjacent to transit vs. rates elsewhere, change in property values following development of new or enhanced transit services and facilities

Modes: all, but particularly street-level or elevated services and facilities

Scope: stop, route, system, region

System Size: any

Audience: public, decision-makers, transit managers, MPOs/transportation planners

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Description: The provision of transit services and facilities can affect property values and lease and rental rates, as well as spur new development or redevelopment that result in higher property values. These effects can be assessed using *property value impact* measures. The amount of new development that occurs can be assessed using *land development impact* measures; property tax revenue that is generated as a result of increased land values can be estimated from *community economic impact* measures.

Example target values: Average real estate value increase per foot closer to transit: $0.002 per square foot (FTA, nationwide statistics)

Major factors: Changes in accessibility, transportation costs, safety, noise, visual quality, community cohesion, and productivity caused by transit services and facilities could affect property values

Data requirements: Areas that are experiencing or will experience changes in accessibility, safety, etc. due to transit services and facilities should be identified and the setting of affected areas should be examined (current land use mix and density, current property values, rate of change of property values and development). Then, the surrounding property values can be assessed.

Note that effects may be different for commercial vs. residential land. Land use could change due to a change in transit services. A transit route could be beneficial in one community and detrimental (or unwanted) in a neighboring community. Methods to obtain data include market studies, property comparisons, case studies, and regression models.

Assessment: Observing and predicting property values may be difficult especially if a market is subsidized, has price controls, or is regulated excessively. Property values react to the economic vitality of an area. When economic growth is stable and a transit project or service is initiated, it may be easier to infer the impact of transit on property values.

Reference: Federal Transit Administration (***54***)

❖ Land Development Impact

Effect of transit services and facilities as a catalyst for land development

Focus: outcomes

Examples: amount of investment in property development or redevelopment around transit stations, number of new residential units developed within walking distance of a transit station

Modes: all, but particularly street-level or elevated services and facilities

Scope: stop, route, system, region

System Size: any

Audience: public, decision-makers, transit managers, MPOs/transportation planners

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Description: The provision of transit services and facilities can act as a catalyst for new development or redevelopment. *Land development impact* measures assess the amount of development that occurs. Changes in property values that occur as a result of transit investments can be measured by *property value impact* measures; property tax revenue that is generated from land that would otherwise be developed for increased roadway capacity can be estimated from *community economic impact* measures.

Example target values: A 1994 study in Indiana found that 6,900 additional parking spaces would be needed if transit service in Indiana was eliminated. In San Antonio, an additional 28,700 parking spaces would be needed without VIA transit service. These would cost from $143 million to $585 million to build.

Major factors: Zoning that allows transit-supportive uses and densities near transit stations, overall community economic health, amount of land available for development or redevelopment near transit stations

Data requirements: Building permit data, from local jurisdictions; value of structures and year built, on parcels near transit stations, from tax assessor

Assessment: These measures have been used in areas where substantial new development or redevelopment has occurred near transit facilities (e.g., Portland, Oregon), as a means of describing the success of transit in attracting and focusing new development. To provide more context, reporting the length of time over which the investment occurred would be useful. Combining *land development impact* measures with *property value impact* and *community economic impact* measures provides a more complete picture of transit's role in shaping land patterns, and the economic benefits that result.

References: McDonald Transit Associates, Inc. (***56***), VIA Metropolitan Transit (***60***)

❖ Resource Consumption Impact

The effect of transit on the rate of consumption of energy and non-renewable resources

Focus: outcomes

Other uses: economic

Examples: energy consumption per person mile, person trip, vehicle mile, or transit facility; percent of fleet powered by non-petroleum-using modes; fuel consumption of the latest model year vs. average fuel consumption of fleet; amount of energy saved per transit trip made, compared to the automobile

Modes: all

Scope: route, system, region

System Size: any

Audience: public, decision-makers, operations staff, transit managers, MPOs/transportation planners

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Description: These measures describe how much energy is being used by transit and how efficiently it is being used. By comparing energy use with transit services to energy use in an auto-only scenario, it is possible to determine transit's effectiveness in saving energy and non-renewable resources.

Example target values: A 1994 study in Indiana found that fuel consumption would increase by 1,030,884 gallons without transit service in Indiana. In San Antonio, the average fuel economy for auto travel is 24.9 passenger-miles per gallon. The average fuel economy for bus travel is 26.1 passenger-miles per gallon (gasoline equivalent).

Major factors: Fuel efficiency of transit vehicles, level of congestion, average speed, regulation of engine shut-off rules, efficiency of fleet management, efficient route design/structure.

Data requirements: Transit energy consumption measures should be relatively easy to determine based on internal transit agency records. Comparisons to automobile energy consumption require ridership data and knowledge of trip lengths.

Assessment: Resource consumption has a more indirect impact on users of transit and community residents than other factors measured by outcome-based measures. Resource consumption affects agencies and their bottom line more than the residents' bottom line. However, taken in aggregate across a large region, perhaps across several states, fuel supply and prices might be impacted. For residents to directly experience the effects of fuel-saving transit vehicles (e.g., through gas prices), the effects must be large and widespread.

The FTA report provides the following ideal measures: cost of transit energy in consumer goods and services, change in energy efficiency per dollar spent by type of intervention, and opportunity costs of converting land for transit purposes (e.g., right of way). Desired measures include energy consumption by mode; efficiency per passenger-mile; and transit consumption of land by area type, including natural habitats and historical landmarks. Other measures include sprawl—the difference between the change in urban household density and suburban household density, fuel consumption per vehicle- or person-mile traveled, number of days in air-quality noncompliance, tons of pollution, and overall mode split or by facility or route.

References: Federal Transit Administration (***54***), McDonald Transit Associates, Inc. (***56***)

❖ Environmental Impact

The effects of transit investment and use on the environment, including air, noise, water, and natural habitat impacts

Focus:	outcomes
Examples:	transit-related air/water pollution per vehicle-mile traveled/1,000 boardings/capita, air quality at transit stops/stations/terminals vs. air quality in other areas, amount of air/water pollution eliminated or reduced due to transit, acres of wetland impacted by transit facility construction, surface area covered by transit facilities, percent of population exposed to X level of air/water pollution
Modes:	all
Scope:	route, system, region
System Size:	any
Audience:	public, decision-makers, operations staff, transit managers, MPOs/transportation planners

Description: Transit services, for the most part, play a role in the reduction of traffic-induced pollution and other types of environmental impacts. However, in localized cases, it is possible that the impacts of a bus lane, for example, could be detrimental to residences near the lane. In the San Francisco Bay Area, increased emissions associated with ferryboats, compared to other modes, were raised as an environmental concern. To determine the pollution control abilities of the transit fleet, emission rates for current model year could be compared with the fleet average. Measures can be tracked by type of pollutant.

Example target values: Emissions reductions due to transit: 2.09 grams of hydrocarbons saved per passenger mile of transit usage (EPA). VIA accounts for 1.5% of daily person-miles of travel but only 0.6% of the three mobile source emissions inventoried by the Alamo Area Council of Governments.

Major factors: Existing level of congestion, delay, fleet composition (e.g., percent hybrid-electric vehicles)

Data requirements: It is necessary to obtain estimates of emissions of each pollutant for each transit vehicle. Most agencies in non-attainment areas have this information. If not, the information could be obtained from the transit vehicle manufacturer. It is probably easier to obtain information about transit emissions and air quality than about water and land quality. GIS software is needed to determine which residents and workers live near transit routes and are thus exposed to a specific level of pollutant.

Assessment: Pollution affects the health of a community's residents and threatens their quality of life. Therefore, assessing the environmental impact of transit is important, especially in urban areas, where the quality of air is already inadequate, and in non-attainment areas. Because transit often alleviates pollution, comparing the impact with and without transit would be helpful in determining the overall impact of transit.

Reference: VIA Metropolitan Transit (***60***)

❖ Noise Impact

Amount of noise produced by transit facilities

Focus: outcomes

Other uses: comfort

Examples: L_{10}, L_{cq}

Modes: all

Scope: stop, route, system, region

System Size: any

Audience: public, decision-makers, operations staff, transit managers, MPOs/transportation planners

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Description: Noise is a byproduct of transit service and transit projects (e.g., construction of infrastructure, etc.) and may affect transit customers, residents of the surrounding community, and places and activities that require a tranquil setting. Noise can be calculated by using weighted decibels. L_{10} and L_{cq} are commonly used. L_{10} is the noise level in dBA exceeded 10% of the time during specified hours. L_{cq} is the composite descriptor taking into account noise variance over time.

Major factors: Tire-pavement interaction; train-car wheels and track interaction; vehicle engines; vehicle exhausts; traffic volume, speed, and proportion of trucks; proportion of stop-and-go traffic; proportion of heavy traffic

Data requirements: After noise effects are identified, noise measurements may be made using a noise meter. Software facilitating noise measurement is available from the FHWA.

Assessment: At busy intersections or other locations, it may be difficult to isolate the effects of transit on aggregate noise levels. In some areas, the noise emanating from transit vehicles may be only a small portion of total noise levels. Monitoring noise levels in those areas may not reflect the contribution of transit to aggregate noise levels.

◆ Visual Impact

Visual effects of transit projects and services on the surrounding built environment

Focus: outcomes

Modes: all, but especially street-level and elevated facilities

Scope: stop, route, system, region

System Size: any

Audience: public, decision-makers, transit managers, MPOs/transportation planners

Description: Transit development brings about changes in the visual quality of the built environment. A strategic approach would be to blend the transit system into the environment. This measure is qualitative rather than quantitative. Targets might involve the notion of "acceptable" or "desirable" visual effects. A transit project or service might be implemented with visual effects that are acceptable or desirable to the community, based on one of the methods described below. If the visual impact of a project or service is not acceptable, changes should be made to the proposed project or service.

Major factors: Construction of new structures, addition of new elements to the landscape, removal of significant community features, addition of visual clutter due to signage, lighting, etc.

Data requirements: One way to measure visual quality is "legibility," the ease with which a landscape's parts can be recognized and organized into a coherent pattern. Obtaining residents' perceptions and preferences is recommended before undertaking a transit project that will affect the landscape. Visual simulation techniques should be used to show residents how the changes will appear. Visualization techniques may be expensive and time-consuming. They include artist's sketches, photo-realism techniques, GIS-based approaches, and virtual models. Methods that are less expensive include visual preference surveys and case studies.

The following steps are suggested in measuring visual quality:

1. Define the study area.
2. Determine changes to be considered and possible alternatives.
3. Select medium/media to simulate the visual environment.
4. Identify the respondents who will observe the environment and assess the likely effects of the project.
5. Develop a procedure to record observer responses to the environment.
6. Analyze the responses and provide feedback.

Assessment: A community that is already visually cluttered may not experience significant changes in its visual quality due to new construction or additions to transit facilities/vehicles. However, the construction of rail service in a rural and picturesque community might produce a greater impact on its residents than a similar project in another, more visually cluttered location. Measuring visual quality would be important before a transit facility is built or service is initiated. Once the service begins or the facility opens, it may be difficult to make substantial changes to improve visual quality.

TRAVEL TIME MEASURES

Travel time measures evaluate how long it takes to make a trip by transit: by itself, in comparison to another mode, or to an ideal value. Two sub-categories of measures are used:

1. *Time*—measures that report results as a time value (e.g., seconds, minutes) and
2. *Speed*—measures that report results as a travel rate (e.g., miles per hour).

The following measures summarized elsewhere in this document also relate to travel time:

- Pass-ups,
- Run time ratio,
- Customer satisfaction,
- Mobility, and
- Mobility index.

◆ Travel Time

Average duration of a passenger trip from origin to destination or over a specified link

Focus: time

Other Uses: service monitoring, comfort, paratransit

Modes: all

Scope: segment, route, system

System Size: any

Audience: public, decision-makers, transit managers, MPOs/planners

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Description: This measure is typically an average for specific routes or corridors but can also be averaged for a system. It is closely tied to transit *travel speed*. Travel time is a traditional transportation performance indicator that can be measured in terms of actual travel time or variability (standard deviation) of travel time. The reduction of the latter does not necessarily mean reducing the former, but it can result in increased customer satisfaction. Comparing travel time with *transit-auto travel time* also can be informative. If the transit-auto ratio or difference is large, it would indicate that more could be done to make route design less circuitous. Travel time can also be expressed as a dollar value; the wage rate in the service area is typically used for business-related trips, and a percentage of the rate is used for non-business-related trips.

Major factors: Scheduling parameters, service guidelines, service area, demand, roadway congestion, dwell time, overall trip length, transfer requirements, number of stops along route, number of boardings/alightings along route, walking time, waiting time, vehicle characteristics, traffic control devices (e.g., traffic signals) along the route

Data requirements: Transit travel time by route or segment, either from schedule data, field data (labor intensive), or AVL equipment. For paratransit, travel time from AVL, scheduling dispatch reports, or driver logs

Assessment: This measure does not relate transit travel time to travel time on alternative modes. This makes it difficult to determine how well the service operates compared to the best-case scenario. Penalties to capture the onerousness of transfers or other events could be included. Average values will not identify bottlenecks or specific locations where travel time could be improved through transit priority treatments or service modifications. Reducing trip times should lead to increased demand for service and improved customer satisfaction, but can reduce overall productivity.

Passengers invariably prefer a trip with no stops or as few stops as possible from origin to destination. If agencies wish to maximize paratransit productivity, longer trips are often needed to group as many passengers as possible, resulting in longer travel times. Agencies that operate shared-ride service often consider the trade-off between productivity and travel time. Passengers perceive that paratransit travel time should be comparable to the automobile. This is the case for taxi service and in situations when no additional passengers are picked up or dropped off while en route.

The ADA has required a minimum performance standard on travel time for complementary paratransit. The travel time should be equivalent in length to the time it takes a fixed-route bus to travel from the same origin to the same destination, including transfers and wait time. Paratransit agencies often set travel time ceilings of 60, 90, or 120 minutes. These ceilings provide a level of quality over and above ADA requirements, and adherence to these ceilings can be assessed with a measure such as *percent of trips made within "X" minutes.* Travel time ceilings are most difficult to meet for long trips, because the reality of the time ceiling limits the number of additional trips that can be provided.

In reality, paratransit travel times are generally less than a comparable fixed-route trip, but not necessarily because the routes are convenient. Often, demand-responsive travel patterns are similar to automobile travel patterns within an area. Travel choices on a fixed-route system are skewed to minimize transfers and travel time. Hence, an ADA paratransit trip is comparable to a fixed-route trip involving a lengthy bus ride with multiple transfers and long walks to bus stops.

◆ Travel Time Variability

Variation in the average duration of a passenger trip from origin to destination or over a specified link

Focus: time

Other Uses: service monitoring, comfort

Modes: all

Scope: segment, route, system

System Size: any

Audience: public, decision-makers, transit managers, schedulers, MPOs/planners, transportation engineers

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Description: Travel time variability can be an important customer satisfaction issue relating to *on-time performance* and *headway regularity*. It measures the variation in length of a customer's trip, which relates to (1) how often persons get to a destination by the expected time and (2) how much extra time persons must allow to reasonably ensure they get to their destination by a certain time. This measure is typically measured after-the-fact, because tools do not yet exist to accurately predict the variability that would occur from a given set of passenger demand and traffic characteristics. Variability can be measured using statistical measures, such as standard deviations or coefficients of variation or by the percent of days that a particular trip took no more than a specified amount of time.

Major factors: Passenger arrival variations from day to day, frequency of non-recurring roadway congestion, number of traffic control devices (e.g., traffic signals) along the route, provision of transit preferential treatments

Data requirements: Transit travel time by route or segment, either from field data collection (labor intensive), or AVL equipment

Assessment: Schedulers can use this measure to help decide how much time to allow in a route's schedule for delays due to congestion. Transportation engineers and transit agency capital planners can use the measure to identify the routes most impacted by travel time variations and then use this information to prioritize transit preferential treatment installations.

◆ Transit-Auto Travel Time

A comparative measure of transit and auto travel times

Focus: time

Modes: all

Scope: route, system

System Size: medium, large

Audience: public, decision-makers, transit managers, MPOs/transportation planners

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Description: The shorter transit travel times are in comparison to the automobile, the more competitive transit is for a given trip. Transit-auto travel time can be applied by trip; by system, as an average door-to-door time; or along a designated segment of a route, where only the in-vehicle times would be compared. It can be expressed as a ratio (transit travel time divided by auto travel time) or as an absolute difference (transit travel time minus auto travel time) as is done in the TCQSM (***2***). Because the lengths of auto trips in small communities tend to be short, particularly in comparison to transit, ratios are better suited for medium and larger systems that will have longer trip lengths; absolute travel time differences work with any size system.

Door-to-door transit times include *walk time* to and from transit, *wait time* for transit, *in-vehicle time,* and *transfer time.* Average walk time to and from transit is typically assumed to be 2 to 3 minutes (based on a maximum 5-minute walk time to a bus stop). Average wait time is typically assumed to be half the headway for frequent services (headways of 10 minutes or less), or the square root of headways for less-frequent services (based on the 1985 HCM). Door-to-door auto times should include walk time from the parking area to one's destination. In large cities, walk time may also need to include time from home to the parked car, in areas where residences typically do not have off-street parking available.

Example target values: Express route travel time should be no more than 150 percent of auto travel time. Travel time for non-express routes should be no more than 200 percent of auto travel time. The TCQSM assigns the following values for *door-to-door transit-auto travel time difference*: "A" =<0 min, "B" = 0-15 min, "C" = 16-30 min, "D" = 31-45 min, "E" = 46-60 min, "F" = >60 min.

Major factors: Roadway congestion, boarding and alighting time, dwell time, number of stops, walking time, waiting time, fare collection time, vehicle condition, trip length

Data requirements: Transit and auto travel times (speed and distance). Transit times can come from schedule data, AVL data, or field checks (labor intensive); auto times can come from the local transportation planning model or field checks. The TCQSM recommends analyzing trips between as many as 15 origin-destination pairs as a compromise between data collection and analysis costs and the need for a comprehensive system analysis.

Assessment: Real-time speed data could be used. The measure will vary by time of day and direction. Penalties to capture the onerousness of transfers or other events could be included. This measure includes important modal comparisons from the passenger's perspective.

Comments: The TCQSM Second Edition is expected to introduce a similar LOS measure for demand-responsive transit, but it will likely be based on a numerical (e.g., 1-8) scale, rather than an alphabetical (e.g., A-F) scale.

◆ Reliability Factor

Percentage of trips that travel time is no more than X% higher than average

Focus:	time
Other Uses:	service monitoring
Modes:	all
Scope:	route, system
System Size:	small, medium, large
Audience:	public, decision-makers, transit planners, operations staff, MPOs/transportation planners

Description: This is a measure of the consistency of travel times, which is important for passengers who need to be at a given location at a certain time. A typical approach is to measure the percentage of trips that are no more than 10% longer than the average travel time.

Major factors: Traffic congestion, traffic incidents, passenger demand variations.

Data requirements: Travel time/speed surveys or automatic vehicle location (AVL) data. A relatively large number of observations are necessary to draw meaningful conclusions.

Assessment: The measure is objective, based on statistical sampling; large sample size is required for meaningful results. The measure can be used for any mode of travel.

❖ Route Directness

The amount of route deviation from a direct path

Focus: time

Other Uses: economics

Examples: ratio of route length to the shortest-path length, additional travel time/distance for a one-way trip, additional travel time/distance compared to an auto making the same trip, number of deviations, difference in overall passenger travel times

Modes: bus (not on fixed-guideway)

Scope: route, system

System Size: any

Audience: service planners

Description: These measures can be used to evaluate deviations from a linear path between points, such as departures from a major arterial to serve an activity center. They are supply-side measures of how fixed-routes are structured, rather than measures that apply to route deviation transit services. Route directness can be reported for an individual route or for the system as a whole.

Example target values: Deviations are limited to 5 to 8 minutes of additional travel time for a one-way trip. Bus travel times should not exceed auto travel times by more than 40%. Deviations must be less than 1 mile per route. The average travel time along the route should not increase by more than 25%. No more than two deviations should be allowed. Route deviations must not lower the average productivity of a route. Chicago's CTA (***28***) allows deviations to existing routes only when it can be shown that time saved by the passengers served by the deviation (by not having to walk as far to a transit stop) outweighs the additional time incurred by passengers already on the bus.

Major factors: Service coverage, service equity, walking distances and environment, connectivity of roadway network, time of day and day of week, system goals

Data requirements: Transit travel time, auto travel time, number of deviations, productivity, distance between route and deviation target, population and employment data

Assessment: This family of measures is an evaluation of the service provided—particularly changes to the service—and not an evaluation of how the service is utilized. It is often used as a service design standard. Its ease of measurement depends on the standard in use and the scope (e.g., a route, a corridor, or the system). There are three passenger points of view to consider and balance: (1) the rider with neither an origin nor a destination along the deviation, who would prefer that the deviation not occur; (2) the rider who now has transit service available at the origin of his or her trip as a result of the deviation; and (3) the rider who can reach more destinations with the deviation. The *difference in overall passenger times* measure can potentially be used to justify increasing stop spacing, by showing an overall travel time benefit to passengers.

◆ (Maximum) Number of Transfers

Service design measure reflecting transit service convenience

Focus: time

Modes: all, but particularly bus

Scope: route, system

System Size: any

Audience: service planners

Description: Limiting the number of transfers required between the desired origin and destination makes transit more convenient and reduces delay and overall travel time.

Example target values: No more than one transfer required between downtown and residential areas

Major factors: Connectivity of desired origins and destinations, population density, employment density, location of stops and stations, quality of transfer (e.g., walking distance, waiting time, and transfer environment), rider delay and travel time

Data requirements: Desired origins and destinations, number of transfers

Assessment: This is a primarily a route design measure, but it can also be used to evaluate existing service. It is an evaluation of the service provided—particularly changes to the service provided—not an evaluation of how the service is utilized. This measure can be difficult to measure at a fine level of detail.

◆ Percent of Trips Requiring Transfers

Measure of transit service convenience

Focus: time

Modes: all

Scope: system

System Size: any

Audience: service planners

Description: Limiting the number of transfers required between the desired origin and destination makes transit more convenient and reduces delay and travel time. Passengers would prefer a one-seat ride from origin to destination.

Example target values: Capital Metro tries to limit transfer activity, measured as a percentage of overall boardings, to less than 25%. The current system average is 22.5%.

Major factors: Connectivity of desired origins and destinations, travel demand between origins and destinations, population density, employment density, location of stops and stations

Data requirements: Desired origins and destinations (requires passenger surveys), number of transfers, number of *linked* trips

Assessment: This is a better measure for system evaluation than *number of transfers*, as it also reflects the number of trips that are made. Surveys are required to identify the percentage of trips that require a transfer.

◆ Transfer Time

Delay incurred or perceived when transferring between transit vehicles

Focus: time

Other Uses: comfort

Modes: all

Scope: stop, system

System Size: any

Audience: service planners, MPOs/transportation planners

Description: This is a measure of how long a rider waits while transferring between vehicles and is a component of *door-to-door travel time*. It can reflect scheduled waiting time, actual waiting time, or perceived waiting time. Previous research has identified that passengers perceive transfer time more negatively than in-vehicle time (e.g., each minute of transfer time is equal to 1.5 to 3 minutes of in-vehicle time, or each transfer adds the equivalent of 15 minutes to a trip).

Example target values: Passengers prefer "organized transfers" in which walk and wait times are less than 2 and 3 minutes, respectively, according to Pursula and Weurlander (***62***). Miami Valley RTA service standards for maximum wait time at transfer points are 20 minutes between local and crosstown services and 10 minutes between suburban services. MTA-NYCT's travel demand forecasting network assumes that each minute of transfer time is equal to 1.5 minutes of in-vehicle time.

Major factors: Number of transferring passengers, headway, on-time performance, transfer environment (e.g., weather and amenities), transfer walking distance, time of day, day of week, route structure (e.g., timed transfer network)

Data requirements: Schedules, actual waiting time

Assessment: This measure is straightforward to calculate from a schedule standpoint, but day-to-day variations in on-time performance can make the measurement of actual waiting time difficult. Transfers are a significant part of perceived service quality, making measuring transfer quality very important.

TCRP Web Document 12 (***6***) notes: "…increased out-of-vehicle time or incidence of transfers is not necessarily a fatal flaw for a service design. It is all a matter of trade-offs. If there are sufficient counterbalancing advantages to the rider gained, for instance, by introducing an additional transfer, the results may be positive, as in the case of several King County [Washington] Metro service consolidations…."

◆ Delay

The difference in travel time between optimal conditions and actual conditions

Focus: time

Other Uses: service monitoring, economics

Modes: all

Scope: stop, route, system, region

System Size: any

Audience: decision-makers, operations staff, transit managers, MPOs/transportation planners

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Description: Excessive delay reduces mobility of transit riders. To calculate the delay, the optimal travel time is subtracted from actual travel time. Delays may be calculated by stop, link, route, system, or on a regional basis. They can also be measured as a rate (e.g., *minutes of delay per mile*).

Example target values: Kowloon-Canton Railway Corporation identified "major" delays as those greater than 20 minutes. MTA-NYCT's 2000 goal for *number of subway delays* was 56,561. The actual number of subway delays in 2000 was 49,927.

Major factors: Network capacity, congestion levels, transit and auto demand, traffic controls, fleet management (e.g., reliability improvements)

Data requirements: Field surveys (requiring extensive data collection), loop detector data, or AVL data; "optimal conditions" data can be obtained during off-peak periods.

Assessment: Similar to *travel time*, small delay reductions per person may not be cost-effective from the passenger's point of view. Larger segments of time allow passengers to use the time savings for another activity, whereas a savings of a minute or two may not be very useful to the passengers. Accumulation of delays over a span of years can slow down route travel time enough to require an additional vehicle to maintain the desired headway, thus causing operating costs to increase. Note that travel demand models forecast delays.

◆ Relative Delay Rate

A dimensionless measure of congestion

Focus: time

Other Uses: service monitoring, economics

Modes: all

Scope: route, system, region

System Size: any

Audience: decision-makers, operations staff, transit managers, MPOs/transportation planners

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Description: The relative delay rate is calculated as the *delay rate* divided by the *acceptable travel rate*. The acceptable travel rate can reflect differences in operation between transit and roadway modes. The relative delay rate can illustrate that a delay rate of 1 minute per mile on a freeway (e.g., 2 minutes per mile of actual travel time versus an acceptable rate of 1 minute per mile) is a much more significant mobility penalty than a similar delay rate on a downtown street (e.g., 5 minutes per mile versus an acceptable rate of 4 minutes per mile). A similar measure is *delay ratio* (delay rate divided by the actual travel rate), which identifies the magnitude of the mobility problem in relation to actual conditions (as opposed to comparing system operations to a standard or target).

Example target values: Zero or less than zero

Major factors: Traffic congestion, schedule accuracy, acceptable travel rate, community input, area type, peak vs. off-peak travel time, mode of travel

Data requirements: Travel time estimated from field studies or empirical relationships, transit schedules, and segment or trip length. The acceptable travel rate (or time) should be determined from local community input.

Assessment: This measure can be used as an index to compare relative mobility on facilities, modes, or systems in relation to standards acceptable to the local community. It has the advantage of transferring community input regarding acceptable travel times to an objective measure for prioritizing improvements.

◆ Travel Rate Index

A dimensionless measure of congestion

Focus: time

Other Uses: service monitoring, economics

Modes: all

Scope: route, system, region

System Size: any

Audience: decision-makers, operations staff, transit managers, MPOs/transportation planners

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Description: The travel rate index is the ratio of travel rate (speed) to free-flow travel rate on each type of facility and by each type of mode, normalized by the vehicle miles traveled or person miles using the system. An example of the index is described mathematically as

$$\text{Travel Rate Index} = \frac{\left(\dfrac{\text{Freeway Travel Rate}}{\text{Freeway Freeflow Rate}} \times \begin{matrix}\text{Freeway}\\ \text{Peak}\\ \text{Period}\\ \text{VMT}\end{matrix}\right) + \left(\dfrac{\text{Principal Arterial Street Travel Rate}}{\text{Principal Arterial Street Freeflow Rate}} \times \begin{matrix}\text{Principal}\\ \text{Arterial Street}\\ \text{Peak Period}\\ \text{VMT}\end{matrix}\right)}{\left(\begin{matrix}\text{Freeway}\\ \text{Peak Period}\\ \text{VMT}\end{matrix} + \begin{matrix}\text{Principal Arterial Street}\\ \text{Peak Period}\\ \text{VMT}\end{matrix}\right)}$$

Major factors: Traffic congestion, passenger volumes, travel rate, vehicle-miles traveled (VMT) or person-miles traveled (PMT), free-flow travel rates.

Data requirements: Travel time/speed studies, free-flow rates or acceptable flow rates, VMT or PMT.

Assessment: Index values can be presented to the public as an indicator of additional time spent in the transportation system due to congestion. The measure can be easily modified to reflect comparison with acceptable travel time by substituting acceptable travel time for free-flow time. The Surface Transportation Policy project multiplied the travel rate index by the percentage of the work force driving to work to develop the *Congestion Burden Index*.

Reference: Texas Transportation Institute (***63***)

◆ Travel Speed

Average speed that transit vehicles travel during revenue service

Focus: speed

Modes: all

Scope: route, system

System Size: any

Audience: transit managers, MPOs/transportation planners

Description: This measure is typically an average for specific routes or corridors.

Example target values: Suggested speed-related LOS criteria for buses on urban arterials from *TCRP Report 26* (***64***) are LOS "A" for speeds >= 16.7 mph, LOS "B" for speeds >= 12.7 mph, LOS "C" for speeds >=8.7 mph, LOS "D" for speeds >= 6.0 mph, LOS "E" for speeds >= 4.7 mph, and LOS "F" for speeds < 4.7 mph.

Major factors: Roadway congestion, boarding and alighting time, overall trip length, transfer requirements, dwell time, number of stops along route, number of boardings/alightings along route, walking time, waiting time, fare collection time, vehicle characteristics, traffic control devices along the route

Data requirements: Speed (travel time and distance) by route or route segment. Travel speeds can be estimated for bus and rail using procedures given in the TCQSM (***2***).

Assessment: This measure does not relate transit travel speed to the speeds of alternative modes, making it difficult to determine how well the service operates compared to the best-case scenario. Penalties to capture the onerousness of transfers or other events could be included. Average speeds will not identify bottlenecks or specific locations where speeds could be improved through transit priority treatments or service modifications.

◆ System Speed

Average speed that paratransit vehicles travel during revenue service

Focus: speed

Other Uses: service monitoring, service contracting, economics, paratransit

Modes: demand-responsive

Scope: system

System Size: any

Audience: decision-makers, transit managers

Description: This is the average speed (mph, km/h) that paratransit vehicles travel while in revenue service. System speed may be measured by time of day, length of trip, or portion of a service area.

Example target values: San Diego Transit Corporation's goal is to "increase system speed to as close to 15 miles per hour as possible" (not including paratransit).

Major factors: Scheduling software capabilities, traffic congestion, road network, trip groupings

Data requirements: Scheduling software, on-time performance data, productivity data

Assessment: Calibrating system speed is critical to both service productivity and on-time performance in a demand-responsive service. If system speed is set too low, on-time performance will be higher as drivers will have more than sufficient time to provide service. However, there will be an inordinate amount of slack time and wasted resources, and productivity will be low.

Scheduling an excessively high system speed generates its own problems. While productivity will improve, the schedule will normally not be attainable by drivers. On-time performance will decline sharply and passenger complaints will rise. Driver dissatisfaction will also develop over being compelled to meet unrealistic schedules, and safety issues can develop if drivers take risks to stay on schedule.

Automated scheduling software has varying levels of capability in terms of adjusting system speed by time of day, trip distance, and service area. Comparing actual system speed to scheduled speed is important in effectively maximizing performance.

There is no definitive answer for the proper system speed for any service. Determining the speed is often a tradeoff between acceptable productivity and acceptable on-time performance. The selected speed should provide the optimum mixture of these two somewhat conflicting factors.

◆ Transit-Auto Travel Speed Ratio

A comparative measure of transit and auto travel speeds

Focus: speed

Modes: all

Scope: route, system

System Size: any

Audience: transit managers, MPOs/transportation planners

Description: This is a comparative measure that can be applied systemwide or by route to compare transit speeds to the speeds of an alternative mode (usually the auto). The smaller the ratio, the more favorable transit service will appear to potential customers. *Transit-auto travel time* is a related measure.

Example target values: A value of 1.0 indicates that transit travel speeds are the same as auto travel speeds, a value less than 1.0 indicates that transit speeds are faster than auto speeds.

Major factors: Roadway congestion, boarding and alighting time, dwell time, number of stops, vehicle characteristics

Data requirements: Transit and auto speeds (travel time and distance)

Assessment: This measure may be helpful in interpreting other measures, particularly after service changes, and in controlling for background transportation system conditions. Real-time speed data could be used. The measure will vary by time of day and direction. It is most useful for comparing the in-vehicle portions of trips, because of the substantial differences in speeds while walking to and waiting for transit, compared to speeds while on a transit vehicle. *Transit-auto travel time* is preferable for assessing door-to-door trips.

SAFETY AND SECURITY MEASURES

Safety and security measures reflect the likelihood that one will be involved in an accident (*safety*), or become a victim of a crime (*security*) while using transit. Measures presented elsewhere in these performance measure summaries that also relate to safety and security are

- Driver courtesy,
- Customer satisfaction,
- Road calls,
- Fleet cleaning,
- Fleet maintenance performance, and
- Maintenance program effectiveness.

❖ Accident Rate

The number of accidents per specified distance or time

Focus:	safety
Other Uses:	service monitoring, service contracting, economics
Examples:	vehicle accidents, customer accidents
Modes:	all
Scope:	route, system
System Size:	any
Audience:	public, decision-makers, transit management

Description: *Accident rate* is the number of accidents that occur per a specified number of miles driven, hours of service provided, or period of time. Accidents can occur on transit vehicles, at stops and stations, or between transit vehicles and other elements of the transportation system. Typically, a value such as 100,000 miles or hours is used as the set time or distance, to avoid working with very small numbers that are harder to report. Accidents can also be reported in terms of passenger boardings or passenger miles. Accident rates are frequently reported by type and severity of accident, differentiating vehicle accidents (collisions) from customer accidents (e.g., slips and falls).

Example target values: CTA's goal is 0.12 accidents per 100,000 miles.

Major factors: Driver safety training and follow-up, vehicle condition (e.g., maintenance history and age), stop/station condition (e.g., cleanliness and design), service area accident rate, scheduling speed

Data requirements: Accident records, odometers, driver logs

Assessment: This is a key service safety measure and normally a key operational focus. Having experienced operators, effectively trained, with well-maintained vehicles normally results in a lower rate. Accident rates can also be divided into preventable and non-preventable accidents. Preventable accidents are those accidents in which the transit driver is normally deemed responsible or partly responsible for the occurrence of the accident.

A *system speed* that results in difficulties with drivers meeting their schedules can increase accidents as drivers rush to their destinations.

Frequency of accidents is normally seen as a level of risk even if the accidents are minor. Major accidents can negatively alter public perception with regard to public safety. A higher level of accidents can lead to increased repair costs, vehicles being out of service, and increased claims and insurance premiums. The transit agency costs that result from vehicle and customer accidents are quantified by *risk management* measures.

The level of accidents is often used as a performance incentive to contractors in an effort to ensure that a quality safety level is maintained.

❖ Passenger Safety

Rate at which incidents or accidents occur in relation to passenger movement

Focus: safety

Other Uses: economics, community

Examples: fatal accidents per passenger-miles/vehicle-miles traveled, injury accidents per passenger-miles/vehicle-miles traveled, property-damage-only accidents per passenger-miles/vehicle-miles traveled, response time, incident/accident durations

Modes: all

Scope: route, system

System Size: any

Audience: public, decision-makers, operations staff, transit management

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Description: Passenger safety measures are a commonly used way of expressing accident rates for transportation modes. Accident types are typically divided into fatal, injury, and property damage only, with separate accident rates reported for each type. *Response time* and *incident/accident durations* (start to end times) also can be useful in monitoring safety.

Example target values: MTA-NYCT's system goal is 2.83 injuries per million customers yearly. Actual injuries per million customers in June 2001 was 3.07.

Major factors: Driver safety training and follow-up, vehicle condition (e.g., maintenance history and age), stop/station condition (e.g., cleanliness and design), service area accident rate, scheduling speed, incident response time

Data requirements: Data for fatalities, injuries, and property damage are collected by transit agencies and reported to the National Transit Database. Response time and incident/accident duration times are not reported to the NTD, but can be estimated based on incident/accident reports from law enforcement agencies and the state department of motor vehicles.

Assessment: Though safety is a traditional indicator, when examined in a regional perspective it becomes a community indicator. Ideal measures mentioned in the *National Transportation System Performance Measures* report include economic and social costs; willingness to pay to prevent property and personal losses from accidents in passenger transportation, including treatment, service, and lost productivity; exposure to accident risk, by mode; and avoided losses and property damage due to safety measures. Desired measures include estimates of property damage, medical treatment and compensation losses due to accidents, by mode; rates of compliance with traffic regulations, including speed limits; number of emergency responses delayed by congestion; comparative accident severity where safety measures are employed vs. not employed; perceived effectiveness of safety measures; accident-related losses by mode; vehicle hours of delay caused by accidents, incidents; and accidents stratified by cause and contribution factors (e.g., physical condition of operation, unsafe operation, operator error, equipment failure, and facility condition).

Reference: Cambridge Systematics (***15***)

◆ Percent Positive Drug/Alcohol Tests

A measure of potential safety issues arising from drug and alcohol abuse

Focus: safety

Modes: all

Scope: system

System Size: any

Audience: decision-makers, transit management, agency staff

Description: Agency staff in positions that can directly impact the safety of passengers and other employees are often required to undergo random drug tests. A high incidence of positive tests can indicate the potential for safety problems.

Major factors: Publicity and enforcement of the agency's drug/alcohol policy, thoroughness of pre-employment background checks

Data requirements: The measure is a product of a random drug testing program. Required data are the number of people tested and the number of positive tests.

Assessment: This measure is an example of a "leading" measure. An upward trend in positive tests indicates a greater likelihood of safety problems in the near future.

◆ Employee Work Days Lost to Injury

A measure of workplace safety

Focus: safety

Modes: all

Scope: system

System Size: any

Audience: decision-makers, transit management, agency staff

Description: An unsafe work environment is undesirable to employees for a variety of reasons and will lead to increased costs for the transit agency if not corrected.

Major factors: Level of attention and training given to safety issues

Data requirements: Payroll or workers compensation records identifying employee time off due to injury

Assessment: This measure is used in a variety of industries to track workplace safety. When tracked by department or by type of injury, it can help focus attention on specific unsafe practices or work environments.

◆ Number of Traffic Tickets Issued to Operators

A measure of bus operator safety

Focus: safety

Modes: bus, paratransit

Scope: system

System Size: any

Audience: decision-makers, transit management, bus operators

Description: Bus operators who drive unsafely pose a risk to the agency's passengers and to other motorists and pedestrians. This measure tracks how many traffic tickets are received over a given period of time.

Major factors: Driver training, agency disciplinary policy, level of field supervision

Data requirements: Motor vehicle records for bus operators

Assessment: Some time may pass between the time that an operator gets a ticket and when it shows up on his or her record. Depending on the level of police enforcement in the area, it may be some time before an unsafe driver is actually ticketed. Tracking complaints related to unsafe driving and field checks by supervisory personnel (see, for example, *percent of buses exceeding the speed limit*) are other means of identifying unsafe operators.

◆ Percent of Buses Exceeding the Speed Limit

A measure of bus operator safety

Focus: safety

Modes: bus, paratransit

Scope: system

System Size: any

Audience: decision-makers, transit management, bus operators

Description: Bus operators who drive unsafely pose a risk to the agency's passengers and to other motorists and pedestrians. Some agencies' field supervisors use radar guns to measure bus speeds in the field; this measure tracks how many buses were found exceeding the speed limit.

Major factors: Driver training, agency disciplinary policy, level of field supervision

Data requirements: Log sheets maintained by field supervisors

Assessment: This technique provides a more timely way of identifying unsafe drivers than relying on traffic ticket records, but it targets only one aspect of unsafe driving: speeding.

◆ Number of Station Overruns

A measure of rail safety

Focus: safety

Modes: rail

Scope: system

System Size: any

Audience: decision-makers, transit management, train operators

Description: A station overrun occurs when the front of a train stops more than a specified distance (e.g., 36 inches) beyond the end of the platform. Beyond the obvious safety issues with doors being located past the platform edge, overruns can be indicative of other potential safety problems. On a manually operated system, station overruns may indicate a problem with an operator's attentiveness or operating skill (e.g., the train is not being stopped where and when the operator is being directed to stop it). For automated systems, station overruns may indicate that system design parameters are not being met. For example, stopping distances in inclement weather are longer than designed. This has safety implications when trains are scheduled to run close together and when emergency stopping situations arise.

Major factors: Driver training, weather conditions, vehicle wheel maintenance

Data requirements: Logs from equipment used to monitor train positions

Assessment: This is a commonly used safety measure on heavy rail systems.

Reference: Interactive Elements, Inc. (***65***)

◆ Number of Fires

A measure of system safety

Focus: safety

Modes: all, but frequently used by rail systems with underground sections

Scope: system

System Size: any

Audience: decision-makers, transit management, maintenance staff

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Description: Fires pose a very serious safety issue, particularly underground. The number of fires is typically measured by location—stations, vehicles, and guideways—and often in terms of severity and cause (e.g., arson, faulty electrical wiring, etc.).

Example target values: MTA-NYCT's 2000 goal for number of subway fires was 1,812. The actual number of subway fires in 2000 was 1,783. The 2001 goal is 1,694.

Major factors: Level of vehicle, track, and electrical equipment maintenance; regular trash removal

Data requirements: Incident logs

Assessment: This measure is commonly used by subway systems.

◆ Number of Crimes (Crime Rate)

A measure of personal security on transit vehicles or in transit facilities

Focus: security

Other Uses: economics

Modes: all

Scope: stop, route, system

System Size: any

Audience: public, decision-makers, transit management

Description: The number of transit crimes is typically reported as crimes against passengers, crimes against staff, crimes on transit property, etc. Crimes can also be categorized by severity.

Example target values: MTA-NYCT reported 14,306 total felonies (including 6,529 robberies and 5,703 grand larcenies) in 1988. SEPTA's projected number of reported crimes per 100,000 trips was 0.47 in 1999; the actual number of reported crimes per 100,000 trips was 0.40. The MUNI goal for Fiscal Year 2001 is to reduce the overall number of crimes by 5 percent.

Major factors: Stop/station design (e.g., lighting and lines of sight); driver training; day versus night; presence of police, cameras, and emergency phones; presence of crowds; rider experience

Data requirements: Crime reports

Assessment: The number-of-crimes measure does not account for unreported incidents and the perception of crime. The perception, according to the literature, is extremely important and is best evaluated by surveys and focus groups or by measures such as the number of incidents of graffiti and the number of security-related complaints.

Personal security while traveling to and from transit stops is also important to passengers, but it is difficult to track, as crimes reported in the general vicinity of transit stops may not have involved transit passengers.

◆ Ratio of Transit Police Officers to Transit Vehicles

A measure of personal security on transit vehicles or in transit facilities

Focus: security

Modes: all, although often not useful for a paratransit-only system

Scope: route, system

System Size: any, although small systems often will not have transit police or security staff

Audience: decision-makers, transit management

Description: The presence of transit police or security staff on board transit vehicles can help deter crime and increase passengers' perceptions of personal security. The greater the ratio of transit police officers to transit vehicles, the greater the chance that a given vehicle will have an officer on board.

Major factors: Time and day of travel, location of police officers (e.g., on board or at stops and stations), other elements affecting personal security (e.g., lighting, cameras, and presence of graffiti), past effectiveness of transit police force

Data requirements: Number of transit police officers, number of transit vehicles

Assessment: This measure is easy to calculate as described above, but it does not reflect where and when officers are placed. To be useful from a passenger perspective, police officers have to be seen on vehicles or in facilities. They also have to be present at the times when transit users are most likely to need them (e.g., late at night or in isolated areas). A measure representing how effectively transit police are deployed will require more extensive data collection, which possibly could include surveys.

◆ Number (Percent) of Vehicles with Specified Safety Devices

A measure of perceived security on transit vehicles

Focus: security

Modes: bus, rail

Scope: system

System Size: any

Audience: decision-makers, transit management

Description: This measure is the number of vehicles (absolute or a percentage) equipped with specified safety devices such as security cameras, intercom systems, emergency alarms, and/or AVL equipment (to facilitate locating a vehicle). The presence of a security camera in vehicles or at stops/stations has been identified in the literature as a means of increasing the perceived security of passengers.

Example target values: Over 600 of LACMTA's new buses have security cameras on board, according to the March 2001 "State of the Bus System" report.

Major factors: Portion of transit vehicle under surveillance, visibility of devices to passengers, use to which cameras are put, response time to incidents, distribution of vehicles with these devices in scheduled service (i.e., when and where are they deployed)

Data requirements: Number of vehicles with specified devices, total number of vehicles in fleet

Assessment: Increasing this performance measure value can result in increased perceived personal security. The effect on crime reduction is not well known.

◆ Number of Incidents of Vandalism

Criminal activity directed against transit property

Focus: security

Modes: all

Scope: system

System Size: any

Audience: decision-makers, transit management, agency/community police, maintenance staff

Description: Vandalism of agency property, which includes such things as graffiti, window etchings, torn seat fabric, etc., diminishes the public's perception of the agency as a whole and of their own potential security or comfort while using transit. Repairing the costs of vandalism also drains resources from other, more productive agency activities.

Major factors: Number of police or security officers assigned to transit duty, presence of security cameras, continually staffed station information booths, lighting levels

Data requirements: Police reports, repair records

Assessment: This measure is particularly useful for tracking over a period of time to evaluate how successful an agency's anti-vandalism efforts are. The costs of vandalism can be assessed by *risk management* measures.

MAINTENANCE AND CONSTRUCTION MEASURES

Maintenance measures assess the effectiveness of the agency's maintenance program, which can impact other performance measures. The one *construction* measure identified evaluates the impacts of transit construction projects on customers. Other measures discussed in these summaries that relate to maintenance and construction are

- Mean vehicle age,
- Customer satisfaction,
- Capital resource utilization,
- Fleet maintenance performance, and
- Maintenance program effectiveness.

❖ Road Calls

The number of unplanned revenue service road calls per specified distance or time

Focus: maintenance

Other Uses: service monitoring, service contracting, safety

Examples: number of road calls, road calls per bus/bus model/failure type per month

Modes: all

Scope: system

System Size: any

Audience: decision-makers, transit management, maintenance staff, capital planners

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Description: A road call occurs when a maintenance vehicle is required to tow or assist a revenue vehicle while it is in service. It is assumed that these incidents are unplanned occurrences. When tracked by bus model, it can identify models that are more or less reliable than the fleet as an average, which can help guide future bus purchase decisions. *Distance between breakdowns* is a related measure.

Example target values: MUNI's goals for Fiscal Year 2000/2001 include 1,500 miles between road calls for Flynn-Arctic Motor Coaches and 1,300 miles between road calls for Boeing Light Rail Vehicles.

Major factors: Quality and regularity of preventive maintenance, original vehicle quality, frequency of severe weather, vehicle age

Data requirements: Maintenance records, vehicle miles

Assessment: A key goal of effective preventive maintenance is to minimize the occurrence of unplanned road calls by ensuring that vehicles are in proper mechanical order. Older vehicles that have reached the end of their specified useful life will tend to have higher maintenance levels, including road calls. Improper preventive maintenance consistently leads to higher levels of unplanned maintenance events, i.e., road calls. Vehicles that are poorly manufactured, or have recurring mechanical or other problems, can also result in high levels of road calls.

A higher level of road calls can also indicate that vehicle safety is weak, since regular preventive maintenance is as essential to vehicle safety as it is to reliability. Extreme weather (temperature or precipitation) can also result in increased road calls.

◆ Distance Between Breakdowns (Service Interruptions)

Measure of transit vehicle reliability

Focus: maintenance

Other Uses: service monitoring, service contracting, safety

Modes: all

Scope: system

System Size: any

Audience: maintenance staff, capital planners

Description: Vehicle breakdowns are one source of reliability problems. This measure is intended for internal agency use in monitoring trends in vehicle breakdowns. It is defined as the vehicle-miles traveled during a defined period, divided by the number of breakdowns. It can be tracked by vehicle type to help with future purchasing decisions. When used to measure reliability, this measure is similar to *missed trips*. *Mean distance between failures* (defined as total revenue miles divided by the total number of mechanical failures resulting in delays) is a similar measure.

Example target values: Houston METRO's goal is 5,000 vehicle miles between service disruptions. MUNI's standard for the Standard and Arctic Motor Coach is 4,000 miles mean distance between failures. SEPTA's 1999 mean distance between failures target for City/Suburban Bus was 6,000 miles; the actual mean distance between failures for City/Suburban Bus was 7,118.

Major factors: Quality of maintenance program, vehicle age, original vehicle quality, roadway conditions, focus on specific vehicles or the system

Data requirements: Number of breakdowns, distance traveled by transit vehicles

Assessment: This measure is easy to track and is appropriate for internal agency use, particularly for use by maintenance and capital planning staff. A more general measure such as *missed trips*, *road calls*, or *on-time performance* would be better to use for regular presentation to the public and decision-makers. Passengers perceive individual breakdowns rather than distances between breakdowns.

◆ Maintenance Work Orders per Bus Model vs. the Total Fleet

Measure of the reliability of particular bus models

Focus: maintenance

Other Uses: safety, comfort

Modes: bus

Scope: system

System Size: medium to large

Audience: transit management, maintenance staff, capital planners

Description: This is measured in two parts: (1) the total number of work orders for each bus model, divided by the number of buses of that model; and (2) the total number of work orders, divided by the total number of buses.

Major factors: Vehicle maintenance, vehicle age, original vehicle quality

Data requirements: Maintenance records for each bus

Assessment: Tracking the amount of repair work required for different bus models can help identify models that are better or worse than average in terms of reliability. This helps guide future bus purchase decisions and guides the assignment of particular bus models to particular routes (e.g., assigning them to routes with lower ridership so that fewer passengers are impacted in the event of a breakdown). The measure assumes that the various bus models are used equally; modifying the measure by service hours would compensate for models that are worked harder than others.

◆ Fleet Cleaning

Indirect measure of vehicle cleanliness

Focus:	maintenance
Other Uses:	comfort
Examples:	percent of fleet cleaned daily, percent of trains cleaned after each trip
Modes:	all
Scope:	system
System Size:	any
Audience:	public, decision-makers, transit management, maintenance staff

Description: Unlike many of the factors typically measured as part of a *customer satisfaction* or *passenger environment* survey, vehicle cleanliness is something that can be readily evaluated with data likely already on hand. This measure can reflect external cleanliness (e.g., washed buses) and/or internal cleanliness (e.g., litter removal) and how often cleaning occurs.

Major factors: Number of vehicles in fleet, number of staff assigned specifically to clean vehicles, vehicle operator diligence in removing litter between trips, passenger courtesy

Data requirements: Records of the number of vehicles cleaned each day or after each trip, total fleet size

Assessment: This measure is an indirect assessment of cleanliness, as it does not reflect the amount of litter, for instance, accumulated per trip or per day, which would more directly reflect what passengers experience. However, the measure does provide an indication of how much effort is being devoted to keeping vehicles clean, without requiring extensive data collection.

◆ Spare Ratio

The percentage of the fleet available to substitute for other vehicles

Focus: maintenance

Other Uses: economic

Modes: all

Scope: system

System Size: any

Audience: decision-makers, transit management

Description: The spare ratio is the number of spare vehicles (*fleet size* minus the *number of vehicles in maximum service*) divided by the *fleet size*. A relatively large spare ratio may indicate an inefficient use of resources, since more vehicles have been purchased (and must be stored and maintained) than are needed for normal operations. On the other hand, too small a spare ratio may indicate potential service reliability problems, as not enough vehicles are available to substitute for other vehicles undergoing regular maintenance or for vehicles that have broken down during the day.

Example target value: Of the 110 agencies surveyed in *TCRP Synthesis of Transit Practice 10* (***48***), 8 have a spare ratio less than 10% and 35 have a spare ratio greater than 20%. Spare ratio in this survey was defined relative to the "total number of required peak period buses."

Major factors: Number of vehicles required for maximum service, original vehicle quality, maintenance department work quality

Data requirements: Number of vehicles in maximum service, total fleet size

Assessment: This measure is easily calculated and is collected by the National Transit Database. Along with the *peak-to-base ratio*, it can reflect how efficiently an agency is able to use its vehicle resources. Because the inputs to the measure change infrequently, this measure does not need to be calculated any more frequently than annually. In contrast, the related *average spare ratio vs. scheduled spare ratio* should be tracked more often (e.g., monthly), as it reflects in part the ability of the maintenance department to complete scheduled maintenance work on time.

Reference: NTD (***1***)

◆ Average Spare Ratio versus Scheduled Spare Ratio

The percentage of the spare fleet actually available to substitute for other vehicles

Focus: maintenance

Other Uses: economic

Modes: all

Scope: system

System Size: any

Audience: decision-makers, transit management, maintenance staff

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Description: This measure has a different focus than *spare ratio*, as it reflects more the ability of the maintenance department to complete scheduled maintenance projects on time, rather than the system's overall efficiency with regard to the number of vehicles it owns. The average spare ratio is calculated from daily records over a set period of time (e.g., monthly or quarterly), based on the number of spare vehicles that were actually available for substitution. The scheduled spare ratio is the same as the *spare ratio*.

Major factors: Number of vehicles required for maximum service, original vehicle quality, maintenance department work quality, maintenance department schedule adherence

Data requirements: Number of vehicles in maximum service, total fleet size, number of vehicles available for service by day

Assessment: This measure provides a check of an agency's assumptions about spare vehicle availability and provides an indirect means of assessing maintenance department work quality. However, the number of vehicles available is also influenced by external factors (e.g., original vehicle quality, crashes, weather conditions, etc.), which are not reflective of the maintenance department's work. *Maintenance program effectiveness* measures provide a more direct assessment about the quality and timeliness of maintenance work orders.

Reference: Maze (***65***)

◆ Average Life of Major Vehicle Components

Planning tool for scheduling component replacement prior to the failure of the component

Focus: maintenance

Other Uses: reliability

Modes: all

Scope: system

System Size: any

Audience: maintenance staff

Description: This measure is useful for maintenance departments to track over a period of time. It allows major vehicle components to be replaced near the end of their functional life but before a breakdown occurs while a vehicle is in service. This allows component replacement to be done as part of a planned maintenance schedule, rather than in reaction to an unforeseen event.

Major factors: Original quality of vehicle components, vehicle operating environment, quality of the preventive maintenance program

Data requirements: Average lifespan of vehicle components by vehicle model

Assessment: When used in conjunction with *average age of major vehicle components*, this measure will help maintenance departments do more work as part of a scheduled maintenance program, rather than in reaction to vehicle breakdowns. The measure is designed for internal department use and would not likely need to be reported to other departments or levels within the agency.

Reference: Maze (***65***)

◆ Average Age of Major Vehicle Components

Planning tool for scheduling component replacement prior to the failure of the component

Focus: maintenance

Other Uses: reliability, economic

Modes: all

Scope: system

System Size: any

Audience: maintenance staff

Description: This measure, a counterpart to *average life of major vehicle components*, is useful for maintenance departments to track over a period of time. Comparing average age to average lifespan assists maintenance departments with their financial planning and maintenance program scheduling (i.e., when will components need to be replaced and how much do they cost?) By having more maintenance occur as part of a scheduled program, rather than in reaction to vehicle breakdowns, service reliability is improved and the number of spares required may be reduced.

Major factors: Original quality of vehicle components, maintenance department financial and workload ability to replace components near the end of their average life

Data requirements: Date of component installation by vehicle model

Assessment: When used in conjunction with *average life of major vehicle components*, this measure will help maintenance departments conduct more of their work activities as part of a scheduled maintenance program, rather than in reaction to vehicle breakdowns. The measure is designed for internal department use and would not likely need to be reported to other departments or levels within the agency.

Reference: Maze (***65***)

◆ Percent of Vehicles with Functioning Climate Control Systems

Measure relating maintenance to passenger comfort

Focus: maintenance

Other uses: comfort

Modes: all

Scope: system

System Size: any

Audience: public, decision-makers, maintenance staff

Description: This measure tracks the number of vehicles with functioning climate control (i.e., heating and/or air conditioning) systems. The type of system being tracked may change over the course of the year, depending on the climate.

Example target values: For MTA-NYCT, the percentage of subway cars with functioning air conditioning, heating, or fans was 97% in the quarter ending June 2001. "Functioning" means that cars have temperatures of 50 to 78 degrees for air conditioning and heating and that 75% of fans operate when the temperature is above 78 degrees.

Major factors: Original quality of climate control systems, maintenance department work quality and workload, vehicle operating environment

Data requirements: Maintenance records, number of vehicles in fleet

Assessment: This measure can also be tracked as part of a *passenger environment* survey. It is listed under the maintenance category because it can also be tracked through maintenance records, without requiring surveys. Maintenance records should provide a daily record of this measure for all vehicles, whereas passenger environment surveys measure only a sample of vehicles.

Reference: Maze (***65***)

◆ Number of Defects Reported by Operators

Measure of how quickly vehicle and infrastructure problems are identified

Focus: maintenance

Modes: all

Scope: system

System Size: any

Audience: transit management, vehicle operators, maintenance staff

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Description: This measure looks at how many (or what percent) of vehicle or infrastructure problems are first reported by non-maintenance staff rather than being identified through maintenance activities or vehicle breakdowns. The sooner a problem is identified, the more quickly it can be repaired, and the less likely it will develop into a serious problem.

Example target values: MTA-NYCT's Department of Subways identified 3,396 handrail defects through ongoing condition surveys and set the goal of eliminating them in 2000. All defects were eliminated in 2000.

Major factors: Vehicle operator and station staff diligence in reporting problems

Data requirements: Maintenance records

Assessment: This measure may be useful for promoting the concept of performance and quality across an agency's departments. For example, vehicle operators and maintenance staff can work together to make sure the vehicles being used in service are as in good condition as possible.

Reference: Maze (***65***)

◆ Customer Impact Index

A measure of the impacts of station renovation or construction projects on passengers

Focus: construction

Other Uses: service monitoring

Modes: all

Scope: stop, route, system

System Size: any

Audience: public, decision-makers, operations staff

Description: The customer impact index is calculated by multiplying the construction/renovation period by (1) the number of passengers utilizing a platform per day and (2) a factor derived from customer survey results. The survey, which uses a numerical scale, includes several key attributes which are important to customers in the transit system.

The index is calculated as

$$\text{Index} = (D*0.01) * (P*0.0001) * S * -1$$

where
D = the number of days of construction,
P = the number of passengers using the platform per day, and
S = the percentage of survey results in the "worse" or "significantly worse" categories.

The fewer the customers that are impacted and the shorter the length of the project, the smaller the index value.

Example target values: For the Times Square reconstruction, the index was calculated using D=140 days, P=62,656 passengers per day, and S=28.3% of results in the "worse" or "significantly worse" categories, resulting in an index of –2.48.

Major factors: Length of construction/renovation period, level of ridership, ability of contractors to mitigate the concerns of transit customers

Data requirements: Data required for the construction/renovation period and the number of passengers utilizing the platform are easy to obtain. In order to conduct the customer surveys, an appropriate sampling methodology must be developed.

Assessment: The index is easy to calculate and comprehend. Customer survey attributes should be ascertained from a focus group, interviews, or surveys with customers. The index, once fine-tuned, could be used for incentive purposes for contractors to finish a job before the scheduled deadline.

Reference: Nakanishi et al. (***67***)

Economic Measures

Economic measures (or "operator-based" measures, reflecting their traditional point of view), evaluate transit performance from a business perspective. Four sub-categories of measures are used in this section:

1. *Utilization*—how well agency resources are used;
2. *Efficiency*—ability to provide service outputs within the constraints of service inputs;
3. *Effectiveness*—ability to meet the demand for transit services given existing resources; and
4. *Administration*—management performance.

Measures that also relate to economic measures, but are presented under other categories, are

- Community economic impact,
- Personal economic impact,
- Resource consumption impact,
- Route directness,
- Delay,
- Relative delay rate,
- Travel rate index,
- System speed,
- Accident rate,
- Passenger safety,
- Number of crimes, and
- Volume-to-capacity ratio.

❖ Ridership

The number of passengers transported

Focus:	utilization
Other Uses:	service monitoring, capacity
Examples:	monthly system-wide boardings, daily linked trips
Modes:	all
Scope:	stop, route, system
System Size:	any
Audience:	public, decision-makers, transit management

Description: This measures the number of individuals boarding and/or alighting at a stop, boarding along a route, or boarding the system as a whole. In the United States, ridership is usually measured in terms of unlinked trips, where all boardings are counted, including transfers. *Linked trips* (one trip from origin to destination, regardless of the number of transfers) are needed for apples-to-apples comparisons with other modes.

Example target values: MUNI's goal for Fiscal Year 2001 was to increase the number of passenger boardings by mode by 2 percent. Fiscal Year 1999/2000 passenger boardings were 96,394,514 for motor coach; 78,460,995 for trolley coach; 41,610,040 for light rail; and 9,206,298 for cable car.

Major factors: Population, disability population, modal alternatives, service quality; also, for paratransit, the effectiveness of the eligibility process

Data requirements: APC/AVL data, scheduling dispatch reports, or driver logs

Assessment: Ridership is a basic measure for transit, on which many other types of economic performance measures are based.

Ridership can be assessed much differently in a demand-responsive service than in a fixed-route service. Increases in ridership in fixed-route service are normally seen as positive. Such increases normally indicate both strong community support and more individuals benefiting from the service, and these increases result in a reduced cost per passenger. Economies of scale usually minimize the increase in overall service cost. Encouraging increasing demand is generally a positive outcome that indicates improving agency success.

Ridership increases in demand-responsive systems are different. Increases in ridership raise service costs and result in minimal economies of scale. As a result, increases in demand are often seen as negative events resulting in increasing financial costs. While general demand-responsive services can limit trips in a variety of ways, ADA paratransit services cannot. Increasing levels of required paratransit service can consume resources from other areas of a transit system's operation, requiring reductions in service to rail and bus systems. The cost per trip of demand-responsive service is normally several times higher (especially in larger transit systems) than that of fixed-route or fixed-guideway service.

ADA paratransit systems often seek to slow or stop the growth of demand-responsive service demand for the overall fiscal stability of the transit agency. These strategies, known as "demand management," work within the framework of the guidelines of the ADA. The goal of these strategies is to provide service to only those individuals who truly qualify and to avoid providing service above the minimum requirement, which often results in increasing demand.

Demand management strategies are not designed to improve service quality but to maintain the fiscal health of the agency within the guidelines of the ADA. As a result, the actual level of ridership is often seen as an outcome of the effectiveness of demand management measures.

◆ Passenger Miles Traveled

Total distance traveled by passengers

Focus: utilization

Other Uses: service monitoring

Modes: all

Scope: route, system

System Size: any

Audience: decision-makers, transit management, MPOs/transportation planners

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Description: Passenger miles traveled is a measure that allows comparisons between different modes by describing the number of persons moved. This measure is largely used as a basic denominator applicable to a number of derived performance measures common to all modes of transportation.

Major factors: Vehicle occupancy, miles of travel (average trip lengths), vehicle capacity

Data requirements: Field surveys, transportation demand model output, trip lengths, and vehicle miles traveled

Assessment: Occupancy data are typically difficult to obtain without physical surveys. Trip length data are difficult to obtain and, when derived from travel demand models, usually unreliable. The measure is useful for inter-modal comparisons.

❖ Capital Resource Utilization

Measures how efficiently capital resources are utilized

Focus:	utilization, efficiency
Other Uses:	maintenance
Examples:	percentage of fleet idle, vehicle miles per peak vehicle, trips per vehicle
Modes:	all
Scope:	system
System Size:	any
Audience:	transit management, transit funding sources

Description: Capital resource utilization standards focus on how efficiently an agency's capital is being utilized to provide revenue. Efficiency goals are set, and resource utilization figures monitor how well these goals are being met.

Example target values: *Percentage of fleet idle*: 24.31% (Broward County Mass Transit, systemwide), *vehicle miles per peak vehicle*: 101,200 (Tri-Rail)

Major factors: System size, service area size, number of employees, fleet size, route length, vehicle miles traveled, passenger miles traveled

Data requirements: Access to financial and operating statistics

Assessment: Resource utilization figures are useful and easy to compute but can be deceptive when taken out of context from an agency's goals. It is important that idealized resource utilization figures be assessed within the context of the agency's operating environment and service goals. *Spare ratio* and *peak-to-base ratio* are similar measures.

❖ Human Resource Utilization

Measures how efficiently employees are utilized

Focus: utilization, efficiency

Examples: revenue vehicle miles per employee, employees per 1,000 vehicle miles, employee cost per revenue mile

Modes: all

Scope: system

System Size: any

Audience: transit management, transit funding sources

Description: Human resource utilization standards focus on how efficiently an agency's employees are being utilized to provide revenue. Efficiency goals are set and resource utilization figures monitor how well these goals are being met.

Example target values: *Revenue vehicle miles per employee*: 11.98 (Metro Dade, systemwide), *employees per 1,000 vehicle miles*: 1.4 (US DOT, nationwide), *employee cost per revenue mile* ($1.03, Broward County Transit)

Major factors: Size of system, number of employees, wages, employee hours worked

Data requirements: Access to financial and operating statistics

Assessment: Resource utilization figures are useful and easy to compute, but can be deceptive when taken out of context from an agency's goals. It is important that idealized resource utilization figures be assessed within the context of the agency's operating environment and service goals.

❖ Energy Consumption

Amount of energy used to provide transit service

Focus: utilization, efficiency

Other Uses: community

Examples: gallons of fuel per vehicle revenue mile, electricity consumed per vehicle revenue mile

Modes: all

Scope: route, system

System Size: any

Audience: transit management

Description: Energy consumption indicators are smaller scale indicators that add more detail to a system's efficiency and cost measurements. They focus explicitly on fuel efficiency.

Example target values: Gallons per revenue vehicle mile – 6.91 (Tri-County Commuter Rail Authority)

Major factors: Fuel price, vehicle fuel efficiency, route length, average speed, number of starts and stops

Data requirements: Extensive data collection is not required. Financial and operating data are all that is required to perform the necessary calculations.

Assessment: This is a useful and straightforward performance measure that can contribute to the creation of more complex and meaningful efficiency/effectiveness measures.

❖ Cost-Efficiency

Ability to provide service outputs within the constraints of service inputs

Focus: efficiency

Examples: cost per vehicle hour, cost per vehicle mile, cost per vehicle trip

Modes: all

Scope: route, system

System Size: any

Audience: decision-makers, transit management

Description: Unlike cost-effectiveness measures, cost-efficiency measures are not related to service consumption. They simply measure a transit system's ability to provide service outputs (e.g., vehicle hours, miles, etc.) as a function of the service inputs (e.g., labor, capital, etc.).

Example target values:

- *Cost per vehicle hour:* $36.56 to $39.85 (Sarasota Transit, FL – bus), $52.52 (SEPTA, Philadelphia – bus), $100.83 (Seattle METRO – bus), $163.83 (BART – heavy rail), $257.90 (Cleveland RTA – Rail)
- *Cost per vehicle mile*: $3.10 (NJ Transit – bus), $5.49 (Miami-Dade Transit – bus), $8.55 (SF MUNI – bus), $9.03 (Tri- Rail, FL – commuter rail), $10.65 (Boston MBTA – heavy rail)

Major factors: Traffic congestion, average speed, route length, service contracting, operating costs, type of service, mode type, and service reliability

Data requirements: Access to financial and operating statistics

Assessment: These types of measures are very common and are utilized by virtually all transit systems when evaluating systemwide performance. However, these measures should be viewed with caution, because they do not measure a transit system's ability to meet the needs of its passengers. These measures only evaluate how efficiently a system can put service on the street, irrespective of where the service is going or how much it is utilized.

◆ Service Miles per Revenue Mile

Vehicle miles driven while in service, divided by vehicle miles driven with passengers

Focus: efficiency

Other Uses: service contracting

Modes: any that operate on a fixed schedule (as opposed to fixed headways)

Scope: system

System Size: any

Audience: decision-makers, transit management

Description: This is a measure of service efficiency: the ratio of total miles driven while in service and total miles driven with passengers. Lower values indicate that the vehicle travels with passengers a greater amount of time while in service. The measure's value will always be 1.0 or greater, as revenue miles are never more than service miles.

Major factors: Demand, scheduling, hours of service

Data requirements: Vehicle odometers, automatic vehicle location equipment, or driver logs

Assessment: This measure is important for assisting in determining per-mile cost, productivity, and maintenance expenses. Some systems use miles traveled as a means for assessing cost and determine cost per mile on that basis. Contracts with service agencies are often based upon that cost.

Better routing and trip grouping (for demand-responsive service) can often reduce mileage and provide service in fewer miles to the same number of people. Mileage is a vehicle-based measure and is best for measuring vehicle costs. Service hours are based on driver labor cost, which is normally the largest single cost of providing service.

◆ Population Served per Vehicles in Maximum Service

Relates the amount of system resources to population

Focus: efficiency

Other Uses: availability

Modes: all

Scope: system

System Size: any

Audience: transit management, service planners

Description: This measure evaluates service availability based on residential population—the smaller the value, the greater the level of access to transit across the system as a whole. This measure is one of twelve inputs to Hartgen's *performance ratio* (***68***).

Example target values: The average for all systems surveyed by Hartgen in 1998 was 3,747.14 people per vehicle in maximum service. The top-ranking system overall in 1998, Santa Monica, scored 459,000 ÷ 135 = 3,400 people per vehicle in maximum service.

Major factors: Population density, capacity of vehicles, network density and connectivity, characteristics of users and non-users, multiple service providers in the service area

Data requirements: Service area population and number of vehicles in maximum service, available from NTD (***1***) reporting data

Assessment: NTD data are readily available locally, but have a 1- to 2-year lead time before they are widely available to others. This measure is very general and does not capture population density, a key influence on the supply of transit service. The measure also does not capture factors that would allow an agency to determine if the "right" number and type of vehicles are being provided in maximum service to particular areas within the system. Comparisons between agencies are difficult when multiple agencies provide service to a given area.

◆ Service Area per Vehicles in Maximum Service

Relates the amount of system resources to service area

Focus:	efficiency
Other Uses:	availability
Modes:	all
Scope:	system
System Size:	any
Audience:	transit management, service planners

Description: This measure evaluates service availability based on service area size—the smaller the value, the greater the level of access to transit across the system as a whole. This measure is one of twelve inputs to Hartgen's *performance ratio* (***68***).

Example target values: The average for all systems surveyed by Hartgen in 1998 was 2.76 square miles per vehicle in maximum service. The top-ranking system overall in 1998, Santa Monica, scored 51 ÷ 135 = 0.38 square mile per vehicle in maximum service.

Major factors: Population density, service area size, network density and connectivity, multiple service providers in the service area

Data requirements: Service area size and number of vehicles in maximum service, available from NTD (***1***) reporting data

Assessment: NTD data are readily available locally, but have a 1- to 2-year lead time before they are widely available to others. This measure is very general and will tend to favor transit systems that serve compact, dense communities. County-wide systems will have a large area to serve but may not need many vehicles to serve it because of low population densities. An agency would find it difficult to use this measure to determine if the "right" number and type of vehicles are being provided in maximum service to particular areas or for the system as a whole. Comparisons between agencies are made even more difficult when multiple agencies provide service to a given area.

◆ Peak-to-Base Ratio

The proportion of additional vehicles required for peak service, compared to base service

Focus: efficiency

Other Uses: temporal availability

Modes: fixed-route

Scope: system

System Size: any

Audience: transit management, service planners, capital planners, schedulers

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Description: The peak-to-base ratio is the *number of vehicles in maximum service* (the greater of the number of vehicles in service in the a.m. or p.m. peak period) divided by the number of vehicles in service during the midday period. It provides an indication of the number of additional vehicles required to serve peak periods, compared to the midday period. The lower the ratio, the greater the ability to use vehicles and operators continuously throughout the day. The ratio will always be 1.0 or higher. It is not applied to demand-responsive services, which generally do not have a defined peak period.

Example target values: The average for all bus systems in 1999, according to the NTD, was 1.7.

Major factors: Population density, service area size, network density and connectivity, multiple service providers in the service area

Data requirements: Number of vehicles used in peak-period and midday service, available from NTD reporting data

Assessment: NTD data are readily available locally, but have a 1- or 2-year lead time before they are widely available to others. Improved midday service would be reflected by a lower peak-to-base ratio, which could be useful for an individual agency to match to one of its goals. However, the measure appears to be more useful for identifying peer agencies with similar operating characteristics.

Reference: NTD (***1***)

❖ Cost-Effectiveness

The ability to meet the demand for transit services given existing resources

Focus: efficiency

Other Uses: service monitoring, service contracting

Examples: farebox recovery ratio, operating ratio, cost per passenger/passenger mile, subsidy per passenger/passenger mile, revenue per passenger/passenger mile, cost per capita

Modes: all

Scope: route, system

System Size: any

Audience: public, decision-makers, transit management, service planners

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Description: Cost-effectiveness performance measures evaluate a transit system's ability to perform its core functions: transport people in a cost-effective fashion. Most of the measures in this family are self-explanatory; the *farebox recovery ratio* is fare revenue divided by total expenses, and the operating ratio is all revenue other than tax revenue divided by total expenses. The former is an indication of how much of the agency's costs are covered by passenger fares; while the latter is an indication of the amount of local subsidy required, after non-fare revenue (e.g., advertising and lease revenues) is accounted for. Some agencies also include FTA operating assistance as part of their non-fare revenue when calculating the *operating ratio*.

Example target values:

- Cost per passenger – $1.38 to $1.80 (Tallahassee Transit – bus), $3.68 (Detroit Suburban, SMART – bus), $2.04 (Orange County, CA – bus), $7.17 (Metro North – commuter rail), $6.38 (NJ Transit – commuter rail)
- Subsidy per passenger – $3.14 (US DOT, nationwide average)
- Operating ratio – 30% (Denver RTD) (called "farebox recovery ratio" by RTD but includes non-fare revenue)

Major factors: Operating budget, passenger volumes, passenger demand, service type, mode type, land use patterns, operating efficiency, trip distance, labor costs, maintenance costs, administrative costs, vehicle costs, and productivity

Data requirements: Financial and operating data

Assessment: These measures provide one of the core evaluations of a transit system's overall performance. They are easily calculated and understood and are frequently used as part of a peer analysis.

While *cost per passenger* in fixed-route systems often declines sharply as ridership increases, the same is often not true for demand-responsive service. Improved scheduling efficiency (e.g., passenger grouping, flexible pickup and travel times, non-circuitous routing, and minimal backtracking) can allow more passengers to be transported in the same or fewer number of service hours, reducing the cost per passenger. However, an increase in the *cost per passenger per hour* may occur if demand is reduced. It should be noted that reducing demand-responsive *cost per passenger* can often be accomplished by reducing service quality: as the *cost per passenger per trip* is reduced (positive service efficiency), service reliability declines (negative customer service).

Cost per passenger is traditionally much higher for demand-responsive service than it is for fixed-route service. The level of productivity is lower, meaning that labor, maintenance, and other costs are spread over fewer passengers. There is also a larger support infrastructure specifically required for ADA paratransit. This administrative and support infrastructure includes reservation agents, dispatchers, and schedulers. Demand-responsive service requires a much lower ratio of dispatchers to drivers, and the fluid nature of demand-responsive scheduling requires more ongoing effort than fixed-route scheduling. *Cost per passenger* is one of the most common means for transit agencies and service providers to determine contract costs for demand-responsive service provision.

The *farebox recovery ratio* and *operating ratio* are used to strike a balance between keeping transit service affordable and having an agency (and particularly its direct users) cover as much of the costs as possible.

◆ Productivity

Total passengers divided by total revenue or service hours

Focus: effectiveness

Other Uses: service monitoring, service contracting

Modes: all

Scope: route, system

System Size: any

Audience: transit management

Description: Productivity is the ratio of total passengers transported divided by total revenue or service hours provided during a given period. The former is the inverse of *cost-effectiveness*.

Example target values: In *TCRP Synthesis of Transit Practice 10* (***48***), 37 of the 86 surveyed agencies reported that 11 to 20 passengers per hour was the minimum acceptable standard for productivity. The City of Corvallis, Oregon, reported 35.59 passengers per revenue vehicle hour (in the mixed demand-responsive and fixed-route system categories). Other actual values reported by transit agencies vary substantially by transit system and mode considered: 54.9 (Chicago Transit Authority – bus), 27.8 (NJ Transit – bus), 72.4 (SF MUNI – Bus), 150.7 (Boston MBTA – rail).

Major factors: Demand, productivity, service area size, system speed, scheduling resources (both software and human). Revenue hours are also affected by cancellations/no-shows and traffic congestion.

Data requirements: Driver logs, AVL equipment, or scheduling software

Assessment: Passenger productivity is a measurement that impacts service cost. While productivity on paratransit is normally lower than fixed-route services, significant productivity enhancements can result in dramatic service cost savings and increases in service. The logistical and regulatory limitations of demand-responsive service (especially ADA complementary service) limit the maximum level of productivity. Productivity rates of greater than 5 passengers per hour in small cities and 2.5 passengers per hour in larger cities are rare.

Demand-responsive service productivity is based upon an array of factors, including service area, density of passengers per square mile, ability to group trips, level of cancellations and no-shows, routing efficiency, traffic, and many others. Maximizing productivity in larger systems involves using scheduling software and adjusting the resulting schedules manually with schedulers and dispatchers. It may also require effective implementation of policies that reduce cancellations and no-shows.

Level of productivity is used as a service incentive or penalty for transit agencies that contract out demand-responsive service. The more aspects of paratransit service that the contractor is responsible for (e.g., drivers, reservations, scheduling, street supervision, and dispatch), the more reasonable it is to use productivity as a service contractor evaluation measure.

Revenue hours are a measurement used by the National Transit Database (***1***) that excludes vehicle hours in which revenue is not provided. Both *passengers per revenue hour* and *passengers per service hour* measure productivity. Given that *revenue hours* are fewer than *service hours*, the productivity ratio is higher when revenue hours are used. However, service hours are usually fixed, while revenue hours occur only while passengers are being transported. As a result, *passengers per service hour* provides a better indication of how well vehicle resources are being utilized over the course of a day, week, or month.

◆ Mobility Index

Passenger miles traveled per hour

Focus: effectiveness

Other Uses: service monitoring, travel time

Modes: all

Scope: route, system

System Size: any

Audience: MPOs/transportation planners

Description: This measure describes the rate at which passengers are moved, blending aspects of utilization and mobility. A related measure is the *corridor mobility index,* which is the *mobility index* divided by a standard value. This standard value could be derived from a freeway or arterial street operating at peak efficiency with a typical urban vehicle occupancy rate. Speed of travel is used in this measure because the index increases as speed and the number of persons moved in the corridor increase.

Major factors: Vehicle occupancy, miles of travel (average trip lengths), vehicle capacity, average travel speed, vehicle volumes, ideal operating volume and speed, traffic control

Data requirements: Field surveys of travel time, speed, and volume; vehicle occupancy studies; ideal flow rates and operating speeds; transportation demand model output; trip lengths; and vehicle miles traveled

Assessment: Subject to all the limitations (which can be substantial) of obtaining good *passenger miles traveled* information, this is a good measure of the mobility offered by a route or system. The measure combines speed of travel and the number of persons moved in the corridor by the transportation system. The measure cannot reflect reductions in travel time resulting from land-use changes; it is a purely transportation system measure. The measure can be used to compare alternative transportation (multi-modal) improvements to traditional automobile-mode-only improvements. The measure is not an easy one to explain or present to the public. Flexibility is offered in defining the normalizing or standard value used in the measure.

❖ Service Effectiveness

Persons transported within the constraints of existing resources

Focus: effectiveness

Examples: passengers per mile, passengers per vehicle

Modes: all

Scope: route, system

System Size: any

Audience: transit management

Description: Service effectiveness measures bridge the gap between service consumption and service outputs. As such, these measures are a critical indicator of a transit system's success and should be heavily relied upon when evaluating a particular system.

Example target values:

- *Passengers per mile*: these will vary substantially between agency: 2.5 (SamTrans – bus), 5.5 (Santa Monica – bus), 2.0 (SEPTA – rail), 7.6 (MBTA – systemwide).

Major factors: Service consumption, reliability, capital assets, fare policy, and land use patterns

Data requirements: These performance measures are typically generated using each transit system's operating statistics reports. Consequently, extensive data collection requirements are not generally required.

Assessment: While there is nothing revolutionary about these performance measures, they continue to serve as useful benchmarks, particularly when compared to a system's peers. These measures are also valuable in conducting a trend analysis for a particular transit agency. As is the case with most indicators, some thought should be given to an agency's situation, including the operating environment, resource constraints, goals/objectives, etc., before making a final assessment of service effectiveness.

◆ Performance Ratio

Index blending 12 measures of system resources and results

Focus: efficiency, effectiveness

Modes: all

Scope: system

System Size: any

Audience: transit management

Description: This measure was developed by Hartgen to compare the performance of major U.S. transit systems. Comparative results have been published since 1991. Twelve measures are incorporated into the index. Five measures relate to resources (i.e., *annual total revenue base per population, fare revenue per unlinked passenger trip, non-fare revenue as a percentage of total revenue [operating ratio], population served per vehicle in maximum service*, and *service area per vehicles in maximum service*). The other seven measures relate to results: *operating expense per vehicle revenue hour, operating expense per vehicle revenue mile, operating expense per unlinked passenger trip, operating expense per passenger mile, population base per 1,000 unlinked passenger trips, vehicle revenue miles per unlinked passenger trip,* and *vehicle revenue minutes per unlinked passenger trip*.

A national average is calculated for each component measure. Each system is then compared to the national average and assigned a performance value based on the ratio of its result to the national average. For example, if the national average for *operating cost per vehicle hour* were $60, a system with an operating cost of $30 per vehicle hour would have a performance value of 0.500, while a system with an operating cost of $90 per vehicle hour would have a performance value of 1.500. Each agency's 12 performance values are averaged to produce an overall performance index for that agency. Finally, all of the agencies are ranked in order from lowest performance index score to highest index score.

Major factors: Service area population, service area size, fare revenue, non-fare revenue, vehicle fleet size, vehicles operated in maximum service, operating costs, frequency, hours of service, passenger demand, route lengths

Data requirements: All of the component measures can be calculated from NTD data. A spreadsheet would be recommended to calculate national averages for each measure, the resulting individual performance ratios, and the overall performance ratio.

Assessment: The measure is intended to provide a national comparison of transit system performance using readily available data. Due to the limitations of the kinds of data reported to the NTD, the *performance ratio* is almost entirely a measure of economic performance. Comparisons between systems do not reflect individual community goals and objectives. These objectives may result in less efficient service from a financial standpoint, but may also result in better service to portions of the community that most require the service and may produce cost savings in other public programs (e.g., welfare).

The rankings do not distinguish between system characteristics. There is a substantial difference between a relatively compact, higher-density system like Santa Monica, the top-ranked system in 1998, and another system that must serve an entire self-contained city as well as other outlying areas. Regional factors, such as amount of poverty, amount of congestion, or the cost of downtown parking, that are not under the control of an agency, will also influence ridership and the resulting index value.

The formula used to calculate the performance index is claimed to weight each factor equally, but in practice does not. A poor performance in one single category can outweigh good performances in several other categories. As an extreme example, MTA-NYCT ranked in the top three agencies for six of the twelve measures, in the bottom four agencies for three of the twelve measures, and in between for the other three measures; yet it ended up ranked 124^{th} out of 137 agencies despite having twice as many top-ranked measures as bottom-ranked measures.

The reason for this result is the way performance values are calculated. A perfect performance value is zero, while an average performance value is one. In practice, five of the top-ranked performance values were 0.39 or higher. In contrast, below-average performance values are open-ended. Six of the bottom-ranked performance values were 4.00 or higher, meaning that a ranking at or near the bottom of just one of these categories would need to be offset by three or more top-ranked performances in other categories just to pull back to average. When a low ranking is due to system circumstances (e.g., cost per vehicle mile, which is higher in very dense areas such as New York that operate many vehicles relatively short distances), rather than any action agency management could take, it calls into question the validity of the comparison being made.

The performance ratio is also susceptible to the problem of autocorrelation. That is, the components of the performance ratio may not be independent. Operating expense per vehicle revenue mile, for example, is not independent of vehicle revenue miles per unlinked passenger trip.

Reference: Hartgen (***68***)

❖ Administrative Performance

Indicators of the overall management performance of a transit system

Focus: administration

Examples: vehicle miles/hours per employee, cost/number of administrative staff to operations staff, labor hours per vehicle hour, passenger trips per employee

Modes: all

Scope: system

System Size: any

Audience: transit management, public officials, transit funding agencies

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Description: The administrative performance standards provide an indication of the level of efficiency with which a transit property can deliver its services. For instance, *revenue vehicle hours per full time equivalent employee* measures a system's ability to put service on the street as a function of the number of employees working for the agency. Comparisons of administrative staff to operations staff reflect the percentage of employees (or employee costs) that are directly involved with putting service on the street.

Example target values: *Revenue hours per employee*: 1.19 to 1.26 (Lynx, Orlando – systemwide), *labor hours per vehicle hour*: 1.6 (RIPTA, systemwide)

Major factors: Organizational structure, service provision approach, use of incentive plans, size of transit agency, and operating environment

Data requirements: Data collection is not a significant barrier with these performance measures. Access to a transit system's financial, operating, and administrative records is generally all that is necessary.

Assessment: Although these performance measures provide very little information regarding a transit system's ability to meet the needs of its customers, the measures do a good job of determining how well an agency is able to utilize its resources to provide transit service. When conducting a management performance review, these measures can provide particularly useful information regarding an agency's organizational structure and administrative efficiency.

❖ Fleet Maintenance Performance

The effectiveness of components of a system's fleet maintenance program

Focus: administration

Other Uses: maintenance, safety, service monitoring

Examples: vehicle miles per gallon, maintenance labor cost per vehicle/mile, maintenance material cost per vehicle/mile, maintenance consumables cost per vehicle/mile, average consumables cost per bus model vs. the total fleet, maintenance cost per vehicle mile per bus model vs. the total fleet, parts inventory value, total value of parts used per month vs. total value of the parts inventory, maintenance labor costs vs. material costs

Modes: all

Scope: system

System Size: any

Audience: transit management, maintenance staff, capital planners

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Description: These measures include both regularly scheduled maintenance and the repair of damaged or dysfunctional vehicles. These measures focus on the costs of fleet maintenance; the related *maintenance program effectiveness* family addresses the results of the department's efforts.

Example target values: *Vehicle miles per gallon*: 3.13 (Broward County Mass Transit, bus)

Major factors: Age of fleet, miles per vehicle, mechanics wages, materials cost

Data requirements: Extensive data collection is not required. Financial and operating data are all that is required to perform the necessary calculations.

Assessment: Measures in this family and the related *maintenance program effectiveness* family will help maintenance department managers "plan, evaluate, and control fleet maintenance performance," according to Maze. Some of these measures will also help capital planners better understand the total cost of operating and maintaining particular vehicle models.

Reference: Maze (***65***)

❖ Maintenance Program Effectiveness

The overall effectiveness of the fleet maintenance program

Focus: administration

Other Uses: maintenance, safety, service monitoring

Examples: mechanics per 1,000 revenue miles, current/average number of open maintenance work orders, average duration of open work orders, number of repeat repairs per month, number of repeat breakdowns per month, amount of corrective maintenance diagnosed during preventive maintenance inspections vs. total corrective maintenance, total labor hours spent on preventive maintenance vs. total labor hours, maintenance labor hours backlogged, total number of preventive maintenance inspections scheduled vs. inspections performed per week, percent of preventive maintenance performed during the prescribed interval, average miles past the prescribed interval that late maintenance inspections occur, average labor time to make corrective repairs, monthly number of stock-outs, average length of time parts on back-order

Modes: all

Scope: system

System Size: any

Audience: transit management, maintenance staff

Description: Another aspect of maintenance performance measures deals with maintenance as a general measure of program effectiveness. These measures generally focus on how well the maintenance department is performing. The *fleet maintenance performance* family provides measures that can assist a maintenance department manager in understanding details related to the costs of running the department.

Example target values: mechanics per thousand revenue vehicle miles: 0.012 (US DOT, nationwide average), maintenance expense per revenue mile: $1.33 (Metro-Dade, systemwide)

Major factors: Age of fleet, miles per vehicle, system size, number of vehicles in fleet, materials cost, maintenance staff size relative to amount of work generated, maintenance staff skill

Data requirements: Extensive data collection is not required. Financial and operating data are all that is required to perform the necessary calculations.

Assessment: These measures provide a number of useful tools to assist the maintenance department manager and higher-level managers in assessing the effectiveness of the maintenance program. Measures in this family help describe the department's workload, the ability to fix problems correctly the first time, the ability of preventive maintenance efforts to minimize vehicle breakdowns, and the frequency that parts are not in stock (which impacts repair time). The longer it takes to repair vehicles, the more vehicles that are not available for service, leading to a higher spare vehicle requirement. Depending on the circumstances, a significant work backlog may indicate there is insufficient staff or repairs are taking longer than they should. Peer comparisons may be helpful in this area. No work backlog, on the other hand, may indicate a larger staff than is needed for the amount of work being generated.

Reference: Maze (***65***)

◆ Number of Late Cancellations and No-Shows

Number of demand-responsive trips scheduled where passengers fail to take the trip

Focus: administration

Other Uses: service monitoring, availability, paratransit

Modes: demand-responsive

Scope: system

System Size: any

Audience: public, decision-makers, transit managers

Description: Late cancellations and no-shows are wasteful to system effectiveness and require additional resources to provide the same level of service. No-shows occur when a passenger fails to appear for the pick-up for a scheduled trip. A late cancellation is defined as a passenger canceling a pick-up less than 2 hours before the trip.

Example target values: MTA-NYCT Paratransit Services had 63,160 late cancellations citywide in 1998. There were 43,083 customer no-shows that same year.

Major factors: Sanctions for frequent no-shows and their effectiveness, customer awareness, service quality, length of advanced reservation

Data requirements:

- Basic — operator logs, scheduling software with no-show/late cancellation report, logging of phone calls received
- Advanced — AVL/MDT (mobile data terminal) playback and time-recorded cancellations

Assessment: Late cancellations and no-shows are inevitable in a paratransit service operation. High levels tend to have a negative effect on service effectiveness and efficiency. A high level of service quality and reliability may result in lower no-shows, since the service is more valued. There is some correlation between the length of allowable advanced reservations and no-shows and late cancellations. Shorter allowable reservations periods (1 to 3 days) normally result in reduced late cancellations and no-shows.

Reduced levels of no-shows and late cancellations can also be achieved by sanctions that are enforced consistently, accurately, and persistently.

Many passengers are often supportive of sanctions because they can see how no-shows are wasteful to the system. Passengers often view chronic occurrences as an abuse of service. Customer perceptions are less positive with respect to late cancellations, since it is not seen as quite as disruptive to service operations.

❖ Employee Productivity

Measures of employee work output

Focus: administration

Other Uses: maintenance

Examples: staff tardiness rate, staff absenteeism rate, pay-to-platform hours, total regular and overtime hours per month, percentage of labor hours that are overtime, overtime per person per week, percentage of overtime paid due to absences, percentage of overtime paid due to backlogged work orders

Modes: all

Scope: system

System Size: any

Audience: decision-makers, transit management, agency staff

Description: This family of measures looks at how much money is being spent on overtime, employee punctuality and reliability, and the amount of time that operators spend operating vehicles compared to performing other tasks.

Example target values: MUNI's Fiscal Year 2000/2001 goal for *percent unscheduled administrative absences* was 5%. Actual *percent unscheduled administrative absences* for the third quarter of Fiscal Year 2000/2001 was 4.3%.

Major factors: Union contractual agreements regarding discipline for excessive absenteeism or tardiness, financial incentive programs for good attendance, cost of employee benefits

Data requirements: These measures can be derived from employee timecard information.

Assessment: These measures are used in a variety of businesses and are not specific to transit. Because labor costs are a major component of an agency's overall operating costs, controlling these costs will help the agency's bottom line. Some overtime can be good from an agency's financial perspective, as the total cost of overtime may be less than paying an additional person's wages and benefits to do the same work. However, excessive overtime is not cost-efficient, nor is overtime incurred due to other employees' absenteeism.

❖ Employee Relations

Measures of employee satisfaction and participation

Focus: administration

Examples: staff turnover rate, number of employee suggestions, number of employee suggestions implemented, number/percent of employees trained, employee satisfaction

Modes: all

Scope: system

System Size: any

Audience: decision-makers, transit management, agency staff

Description: These measures mostly provide indirect indications of employee happiness. They also measure an agency's commitment to improving staff skills and seeking out and implementing employee ideas. The exception is *employee satisfaction*, which is a more direct indication, based on surveys similar to those described under *customer satisfaction*. The *staff turnover rate* is the number of employees who left the organization over a period of time (typically annually) compared to the average number of employees during that time. The *number/percent of employees trained* needs to specify the particular type of training, such as responding to unhappy customers or CPR training. The *number of employee suggestions* is an indication of how involved employees are in improving the organization; the *number of employee suggestions indicated* is an indication of how seriously management is committed to adopting employee ideas for improving performance.

Major factors: Work environment, relative wages compared to other opportunities, employee-management relations

Data requirements: Employment records, suggestion program records, employee skills database. A survey is required for a detailed assessment of employees' satisfaction with various aspects of their work. This survey should be conducted regularly and consistently.

Assessment: These measures are used in a variety of businesses and are not specific to transit. Because training new employees costs money, and it takes time for new employees to be able to fully perform all of the aspects of their jobs, it is in the agency's best financial interest to keep its employees happy and retain them. High employee morale will lead to higher levels of employee performance, which will translate into improved agency performance.

❖ Risk Management

The cost of accidents and other kinds of preventable losses

Focus: administration

Examples: vehicle liability losses, general liability losses, property losses, workers compensation payments, other liability losses

Modes: all

Scope: system

System Size: any

Audience: decision-makers, transit management, finance staff, legal staff

Description: Risk management measures assess how much of the agency's costs are preventable losses. The measures focus on particular types of losses. *Vehicle liability losses* include costs to repair damage to transit vehicles or to other vehicles damaged by transit vehicles. *General liability losses* include such things as customer injuries. *Property losses* cover damage to transit agency property and damage to other property caused by transit vehicles. *Workers compensation payments* cover injuries that employees suffer while working. *Other liability losses* include less common types of losses, such as environmental liability (cleaning up spills), contractual liability, civil rights liability, sexual harassment liability, and director/officer liability.

Major factors: Work environment safety, employee safety training, vehicle operator training, employee workplace conduct

Data requirements: Financial records, including any insurance records, that detail these kinds of costs

Assessment: Safety and security measures quantify how often accidents occur, whereas risk management measures quantify the costs associated with those accidents. However, these measures go beyond accidents to cover the entire range of issues where a transit agency may incur losses.

CAPACITY MEASURES

Capacity measures assess the ability of transit facilities to move both *vehicles* and *people*. Capacity-related measures shown under other categories consist of

- Service denials,
- Seat capacity, and
- Ridership.

◆ Person Capacity

Person-carrying capacity of a transit route or facility

Focus: persons

Modes: all

Scope: stop, route, facility

System Size: any

Audience: operations staff, transit planners, MPOs/transportation planners, engineers

Description: *Person capacity,* as defined in the TCQSM, is "the maximum number of people that can be carried past a given location during a given time period under specified operating conditions without unreasonable delay, hazard, or restriction, and with reasonable certainty." It is typically measured in passengers per hour.

Person capacity can be described as either (1) the number of people that can be carried under existing conditions (based on the current schedule) or (2) the ultimate number of people that could be carried, with no limitation on the supply of transit vehicles. In the former case, person capacity is constrained by budget constraints or lack of demand warranting additional service. In the latter case, person capacity is constrained by the *vehicle capacity* of a transit facility.

The number of people that can be carried under current conditions is

(Number of vehicles scheduled) * (Average maximum schedule load per vehicle) * (peak hour factor)

The maximum number of people that could be carried on a facility is

(Facility vehicle capacity) * (Average maximum schedule load per vehicle) * (peak hour factor)

The *maximum schedule load* is set by agency policy and represents a design level of crowding that passengers are normally willing to tolerate. Sufficient vehicles should be scheduled so the maximum load is not exceeded and no *pass-ups* occur. The peak-hour factor (PHF) represents the average hourly vehicle loading as a percentage of the peak 15-minute vehicle loading. It is used to reduce capacity so that not all of the offered capacity will normally be utilized. Using a PHF allows for variations in passenger arrivals and minimizes the possibility that overcrowding or pass-ups will occur. A PHF of 1.0 indicates either an even passenger arrival rate during the hour (unlikely to occur) or demand exceeding capacity, resulting in every available space on every vehicle being utilized and passengers unable to board the first vehicle to arrive. The TCQSM provides recommended PHFs for design. When passenger volumes are known, the PHF is calculated as

PHF = (hourly passenger volume) / (4 * peak 15-minute volume)

Rail systems can use (number of trains scheduled) * (average number of cars per train), and the average maximum schedule load per car to calculate the person capacity of existing service.

Major factors: Vehicle *passenger capacity*, facility *vehicle capacity*, number of vehicles scheduled, agency or regulatory passenger loading standards, passenger tolerance for crowding, and passenger arrival characteristics

Data requirements: Vehicle maximum schedule load, scheduled frequency, facility vehicle capacity, and passenger volume data or default peak-hour factor. Calculating *vehicle capacity* requires a number of other inputs, which are described under that measure. The TCQSM provides definitions for these factors, as well as default values for many of these factors for use when local data are not available.

Assessment: This measure is well suited for alternatives analysis of new facilities and for assessing the impacts of traffic on transit service. An agency's passenger loading standards directly affect person capacity—the more crowding that is tolerated, the more people that can be carried with a given number of transit vehicles. It is also suited for use in comparisons of the costs of adding transit capacity versus adding roadway capacity.

It is important to apply an appropriate peak-hour factor to the calculation of person capacity to get a realistic estimate of the number of people that can be carried consistently during an hour. Not incorporating a peak-hour factor into design calculations may lead to over-optimistic estimates of the number of people that can be carried, resulting in pass-ups and platform queuing during peak periods.

Reference: TCQSM (***2***)

◆ Passenger Capacity

Person-carrying capacity of a transit vehicle

Focus: persons

Modes: all

Scope: vehicle

System Size: any

Audience: operations staff, transit planners, MPOs/transportation planners, engineers

Description: This measure reflects the number of people an individual transit vehicle can reasonably carry and is an input for calculating *person capacity*. It is typically expressed as a *maximum schedule load,* the maximum number of passengers desired on any given vehicle. This value is typically less than the maximum number of people that could be packed into a vehicle (crush loads). It accounts for passenger comfort and operational problems that develop when people are unable to get quickly to and from the vehicle doors. *Passenger load* reflects the number of people actually carried.

Example target values: The Chicago CTA's service guidelines (***28***) match maximum scheduled loads to demand. Where demand is lower, fewer vehicles are scheduled; but maximum schedule loads are also lower, so passengers are more likely to get a seat. For example, when there is a demand of 30 to 60 passengers during the peak 30 minutes, on a route using standard buses, service is scheduled so the average load does not exceed 40 passengers per bus. When there is a demand of 90 to 125 passengers during the peak 30 minutes, service is scheduled so the average load does not exceed 50 passengers per bus. When demand exceeds 165 passengers in the peak 30 minutes, service is scheduled so the average load does not exceed 60 passengers per bus. Commuter rail operators typically aim to provide a seat for every customer, with no standees. The number of passengers allowed on ferries is governed by Coast Guard regulations relating to, among other things, the number of staff on the vessel.

Major factors: Number of seats provided, standing area provided, vehicle length and width, interior layout, passenger tolerance for crowding, passenger comfort issues

Data requirements: The number of seats is readily available from vehicle specifications. Area available for passengers to stand is not a routine specification and may need to be calculated for each vehicle type. The TCQSM presents guidelines on the area per passenger for different comfort levels. Passenger loading standards may be available locally, or defaults can be used from the TCQSM.

Assessment: This measure is often used as an input to other measures, such as *person capacity* or *passenger load*. Stand-alone applications include use in service standards (illustrated above) and in comparing the number of people that can be carried by different vehicle types.

Reference: TCQSM (***2***)

❖ Terminal (Station) Element Capacity

Number of people that can use a particular element of a transit station in a given period of time

Focus: persons

Examples: platform capacity, walkway capacity, stairway capacity, escalator capacity, elevator capacity, doorway capacity, fare gate capacity

Modes: all

Scope: station element

System Size: any

Audience: operations staff, engineers

Description: This measure reflects the maximum number of people that can be processed by a particular portion of a transit terminal or station in a given period of time, typically 1 hour. The most restrictive capacity element will constrain the number of passengers that can pass through the station from entrance to platform, or vice versa. For some station elements—platforms, walkways, and stairways—capacity is based on providing a design comfort level for users, measured by an average area per pedestrian. For mechanical elements—escalators, elevators, doorways, and fare gates—capacity is the number of people that can be processed by that element during a given period of time. The need to meet fire code evacuation requirements may result in a need for designing for more capacity than would be needed to provide a particular comfort level.

Part 5 of the TCQSM 2nd Edition provides procedures for calculating the capacity of various station elements.

Major factors: Design passenger comfort level, walkway width, stairway width, platform area, escalator width, escalator speed, elevator interior area, elevator length, elevator speed, number and type of fare gates

Data requirements: See the major factors.

Assessment: This measure can be used to evaluate the level of crowding that occurs at rail and bus stations and terminals and to identify bottlenecks within the station. *Equipment reliability* can be used to assess how often the full capacity of mechanical elements (particularly ticket machines and fare gates) is available; the station element capacity procedures can be used to determine the impacts of out-of-service equipment on passenger comfort and travel time through the station.

References: TCQSM (***2***), Fruin (***69***)

❖ Vehicle Capacity

Number of transit vehicles that can be served by a stop, route, or facility in a given time

Focus: vehicles

Examples: loading area capacity, bus stop capacity, bus facility capacity, line (train) capacity, vessel (ferry) capacity

Modes: all

Scope: stop, route, facility

System Size: any

Audience: operations staff, transit planners, MPOs/transportation planners, engineers

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Description: This measure reflects the maximum number of vehicles that can pass a given location during a given period of time, with no constraints on the supply on vehicles. In contrast, *frequency* reflects the number of vehicles scheduled during a given period of time.

Vehicle capacity is directly related to the minimum *headway* that can be achieved between successive transit vehicles. Headway is usually constrained by the stop or station with the longest dwell time (the "critical stop"). For buses, capacity is also related to the number of loading areas (berths) at the critical stop, degree of interaction with other traffic, bus stop patterns, and traffic signal timing. For rail, the type of train control system is also a key factor in determining the minimum headway. Less frequently, at-grade junctions, turnbacks at the end of the line, power supply constraints, or single-track two-way operation can prove to be constraining factors for rail capacity. An extra time allowance (operating margin) usually is incorporated into the minimum headway to allow for longer-than-normal dwell times and to avoid delays to subsequent transit vehicles needing to use the stop or station.

Parts 2 through 4 of the TCQSM 2nd Edition provide procedures for calculating bus, rail, and ferry capacity, respectively.

Major factors: Passenger service times at stops, traffic congestion, amount of priority given transit (e.g., exclusive facilities, transit priority measures), traffic signals, train control systems, walkway length between ferry passenger waiting area and dock, transit vehicle length, right-of-way type

Data requirements: Average dwell time; dwell time variability; traffic signal timing; design operating margin; scheduled bus volumes; traffic volumes; bus stop location, size, and configuration; train control system type; vehicle length; right-of-way type. The TCQSM provides definitions and default values for many of these factors if local data are not available.

Assessment: This measure is well suited for alternatives analysis of new or expanded facilities. It can also be used to evaluate changes in capacity resulting from changes in transit operations (e.g., fare payment method), infrastructure (e.g., train control system), or increased traffic congestion. Vehicle capacity has a direct influence on transit *travel speeds*: as the number of buses scheduled approaches capacity, travel speeds drop dramatically. Vehicle capacity also decreases as the number of non-transit vehicles sharing the facility increases.

Reference: TCQSM (***2***)

◆ Volume (Demand) to Capacity Ratio

Percentage of capacity that is being utilized

Focus:	vehicles, persons
Other Uses:	economics
Modes:	all
Scope:	stop, route, facility
System Size:	any
Audience:	public, decision-makers, operations staff, transit planners, MPOs/transportation planners

Description: This measure is similar to the volume-to-capacity ratio measure used in automobile modal analysis. It typically reflects the percentage of *vehicle capacity* being utilized but can also reflect (less accurately) the percentage of *person capacity* being utilized, subject to assumptions about vehicle occupancies and passenger arrival rates. It can reflect actual volumes, which may be constrained by bottlenecks, or demands. Demand is the number of people that would like to use the link, facility, or service in a given amount of time and requires a transportation planning model to calculate. The volume-to-capacity ratio is a multi-modal measure.

Example target values: A value of 1.0 indicates capacity. Values less than, but close to, 1.0 indicate near-capacity conditions that may impact transit travel speeds and reliability. Values much less than 1.0 indicate under-utilization of a facility. Values greater than 1.0 indicate demands to use transit that exceed its capacity.

Major factors: Traffic congestion; passenger volumes; alternative modes available; vehicle capacities; vehicle occupancies; traffic, geometric, and roadway characteristics that impact capacity

Data requirements: Various traffic, geometric and roadway data used to determine capacity, including traffic volumes, vehicle classification, vehicle capacities, vehicle occupancy data, and others depending on the level of detail and accuracy desired. The HCM and/or the local transportation planning model provide defaults for many of these values. If the movement of persons (rather than vehicles) is being evaluated, *passenger capacity* is also required.

Assessment: This measure is best suited for long-range planning, alternatives analysis of new facilities, and assessment of the impacts of traffic on transit service. This measure may be easy for typical transportation professionals or transportation decision-makers to understand, as they are likely already familiar with the measure's use for the automobile mode. The measure is objective and can be scaled in terms of accuracy and level of detail.

INDEX OF PERFORMANCE MEASURE CATEGORIES

PRIMARY CATEGORIES

SECONDARY CATEGORIES

PARATRANSIT

ADA ACCESSIBILITY

SERVICE CONTRACTING

COMFORT

INDEX OF PERFORMANCE MEASURES

All of the performance measures included in the summary are listed below, along with the pages where they are discussed. Names of primary measures and families of measures are shown capitalized, while measures that are part of a larger family of measures are lower case.

— APPENDIX A —

CUSTOMER SATISFACTION SURVEYING

INTRODUCTION

Traditionally, transit agencies have focused on operations: getting the buses "out there" and the trains "running." Most agencies did not begin to focus on the customer until the 1990s; and, even now, smaller agencies may be faced with budget and resource constraints and cannot give priority to customer satisfaction and service quality issues. Typically, larger agencies have more resources as well as more choice riders and, therefore, have taken the lead in trying to measure customer perceptions of service quality. For example

- MTA-NYCT was interested in public attitudes toward transit services as early as 1982 and began a study ("Citywide Survey") the following year to establish a baseline of public perceptions of the service quality of its transportation services. A Passenger Environment Survey assessing the transit environment from the customer's point of view was initiated in the late 1980s. In the early 1990s, MTA-NYCT established a customer services department and, in the mid-1990s, it initiated a customer-oriented performance indicator program.
- In the early 1990s, the Massachusetts Bay Transportation Authority (MBTA) began developing ways to monitor service quality on high-frequency rail transit lines.
- The Chicago Transit Authority (CTA) and the San Francisco Bay Area Rapid Transit District (BART) have initiated transit customer satisfaction surveys to assess customer perceptions of service quality and overall levels of satisfaction.

A few smaller agencies (e.g., Lansing's CATA) have well-developed customer satisfaction survey programs and have implemented some innovative methodologies in the analysis and interpretation of survey results.

Surveys reveal customer perceptions of transit services and of specific service quality attributes such as *cleanliness*. Because the entire population of customers is too large to survey, a representative sample is selected. Before the actual surveys are performed, survey questionnaires should be carefully designed and a sampling methodology developed to ensure a high response rate and unbiased data collection.

If the sample is statistically valid, the results can be generalized to a larger population. The steps involved in customer satisfaction research using surveys are described in Figure 13 below.

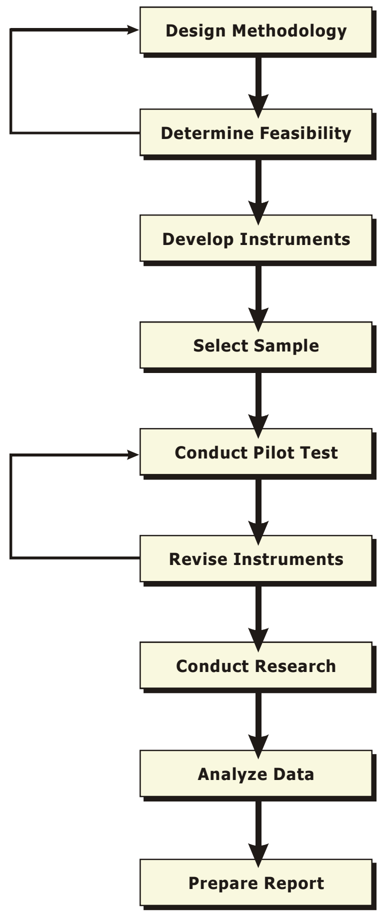

Figure 13. Customer Satisfaction Research Process (*70*)

Sample size is based on how much error can be tolerated, the desired confidence level, and how varied the population is with respect to the characteristics of interest. The larger the sample size, the greater the accuracy of the results but also the greater the survey costs. If a high response rate could be obtained from a reasonable sample size, survey costs could be minimized.

A worksheet on calculating the costs of a survey is provided by Walonick (***70***). This worksheet is reproduced in Figure 14.

Table 18 shows the required sample sizes at the 95% confidence level; that is, 95% of the time a random sample is drawn, the sample will provide an estimate that is within ±5% or ±10% of the true population value. If a 50% response rate is expected, these estimates would need to be doubled.

Table 18. Sample Size at the 95% Confidence Level

Population Size	+/- 5%	+/- 10%
25,000	378 (most conservative)	96 (most conservative)
50,000	381 (most conservative)	96 (most conservative)

	Hours	Duration
1. Goal clarification	________	________
2. Overall study design	________	________
3. Selecting the sample	________	________
4. Designing the questionnaire and cover letter	________	________
5. Conducting the pilot test	________	________
6. Revising the questionnaire (if necessary)	________	________
7. Printing time	________	________
8. Locating the sample (if necessary)	________	________
9. Time in the mail & response time	________	________
10. Attempts to get non-respondents	________	________
11. Editing the data and coding open-ended questions	________	________
12. Data entry and verification	________	________
13. Analyzing the data	________	________
14. Preparing the report	________	________
15. Printing and distribution of the report	________	________

Figure 14. Customer Satisfaction Survey Costs Worksheet (*70*)

There are several sampling methods that can be used to determine who will receive the survey. For typical surveys, a random sample will suffice. For instance, if subway riders are being targeted, a random sample of subway riders should be drawn. However, if market segmentation information is desired (e.g., customer satisfaction levels based on income level), a stratified sampling technique might be useful. Various other types of sampling techniques exist, such as systematic sampling, convenience sampling, and snowball sampling.

There are various survey methods. The following have been used to measure customer satisfaction of transit customers:

- Impact score approach,
- Customer Satisfaction Index,
- Revealed preference/stated preference techniques, and
- Structural equation models.

An additional method, ServQual, has not been used specifically in transit, but it has been used widely in market research and has potential for use in transit.

These methods are discussed in the following sections.

IMPACT SCORE APPROACH

The impact score approach determines the relative impacts of attributes on overall satisfaction by measuring relative decreases in overall satisfaction when a problem with an attribute is reported. Areas of weakness can be identified by the transit agency, and priorities can be developed to address these areas based on the impact scores. Survey respondents rank the importance of specific service attributes and indicate their overall satisfaction with the system using a likert (e.g., 1 to 5) scale. The impact score approach involves the following steps (***4***):

1. Determine which service attributes have the greatest impact on overall customer satisfaction. Calculate the percentage of customers experiencing a problem with that attribute within past 30 days. Compare the mean overall ratings for customers who experienced a problem and for those who did not. The difference is the *gap score.* Use a *t*-test to determine the statistical significance among gap scores.
2. List the attribute problem incidence rate (0 to 100%) for each attribute in a column next to its gap score.
3. Create the *impact score* by multiplying the overall satisfaction gap score by the attribute's problem incidence rate.

While gap scores will not change significantly over time, problem occurrence rates can change. Therefore, subsequent tracking surveys can be done by collection of overall satisfaction and problem occurrence rates.

Table 19 demonstrates the impact score calculation process for reliability of bus service.

Table 19. Sample Impact Score Calculation

Mean Satisfaction with Problem	Mean Satisfaction without Problem	Gap Value	Percent with Problem	Impact Score
5.8	7.5	1.7	.50	.85

For instance, on a scale of 1 to 10, 5.8 reflects the mean satisfaction score for customers who had a problem with reliability within the past 30 days, and 7.5 reflects those customer who did not have a problem. The gap value is the difference between the two scores: 1.7. If 50% of surveyed customers did have a problem with reliability, then the impact score would be 1.7 x 0.50 or 0.85 (***4***).

Quadrant analysis may be used to set priorities for action. For instance, CATA in Lansing, Michigan, sets improvement strategies by using this analysis method, as illustrated in Table 20. Based on the gap score for each element and the incidence of problem occurrence, the quadrants present indicators of potential problems and opportunities. The attributes with high gap scores as well as an above-average incidence of problem occurrence receive first priority; areas that are critical drivers of customer satisfaction and have an above-average problem incidence also receive attention by CATA.

Table 20. Sample Quadrant Analysis (*71*)

Gap Score	Problem Occurrence	
	High	**Low**
High	Opportunities	Strengths
Low	Non-Critical	Maintenance

CATA's survey includes the following three questions related to customer loyalty (***71***):

- Overall, how satisfied are you with riding CATA?
- How likely are you to continue to ride CATA in the future?
- How many relatives, friends, or co-workers have you encouraged to ride CATA in the past year?

Analyzing the composition of the loyalty responses and shifts in the proportion of loyal vs. less loyal riders produces the following four loyalty segments:

- *"Secure" riders*: those who provided the highest rating ("extremely satisfied") to all three questions;
- *"Potentially vulnerable" riders*: those who gave the highest rating to two of the three questions;
- *"Vulnerable" riders*: those who gave the highest rating to only one of the three questions; and
- *"Highly vulnerable" riders*: Riders who did not give the highest rating to any of the three questions.

Based on four questions related to price sensitivity on CATA's survey, customer perceptions of the value of their transit ride and customer resistance (inelasticity) over a range of fares can be measured:

- *Reasonable Fare*: what fare would you expect to pay for a one-way ride to receive good service for the fare paid?
- *Expensive*: at what point would the amount you pay for a one-way ride be expensive but you would continue to ride?
- *Too Expensive*: at what point would the amount you pay for a one-way ride be so expensive that you would stop riding or ride less often?
- *Too Low*: At what point would the amount you pay for a one-way ride be so low that you would be concerned about the quality of service?

At the Indifference Price Point, an equal number of respondents believe that the fare is "reasonable" as believe it is "expensive" and the remaining respondents are indifferent. This point is the price at which the maximum number of respondents are indifferent.

The Optimum Price Point is the price at which an equal number of respondents perceive the price as "too low" and "too expensive." It is the point at which price-related resistance to paying an increased fare is at its lowest point.

"Stress" is defined as a situation in which a number of riders believe that the current fare is too high. The larger the separation of the "Optimum Price" and the "Indifference Price," the greater the "stress."

The range of prices between the "Point of Marginal Cheapness" and the "Point of Marginal Expensiveness" is considered the "Range of Acceptable Prices or Fares." Any price below this range will be unlikely to generate new customers, and any price above this range may have an adverse impact on revenues. The "Point of Marginal Cheapness" is the point at which the number of riders who view the price as "too low" equals those who view the price as "not reasonable." The "Point of Marginal Expensiveness" is the price at which the number of riders who believe the fare is "too expensive" is the same as the number who believe the fare is "not expensive."

CUSTOMER SATISFACTION INDEX

The Customer Satisfaction Index (CSI) research project team asked respondents in five transit districts to rate their level of overall satisfaction with their last transit experience, according to a five-point scale: 5 = "Very Satisfied," 4 = "Somewhat Satisfied," 3 = "Neither Satisfied nor Dissatisfied," 2 = "Somewhat Dissatisfied," and 1 = "Very Dissatisfied." Respondents were also asked to rate 35 to 40 attributes using a five-point scale: 5 = "Excellent" to 1 = "Poor" (**72**).

The analysis methodology involved the following steps:

1. Between 35 and 40 attributes were grouped into factors using factor analysis.
2. These factors were regressed against overall customer satisfaction, which was considered the dependent variable to determine which ones contributed the most to the prediction of overall customer satisfaction.
3. Based on the regression analysis in No. 2, the factors were expressed by the weight assigned to them. Weights of 17% or higher were deemed "highly important"; 11 to 16% were "moderately important"; and the rest were of "low importance."
4. Index scores and factor scores: The total sample average was set to 100, and then each individual city was compared against the average.
5. Crucial factors are the factors with the greatest gaps between the index score and maximum possible index score.
6. Loyalty analysis: To answer the question, "What attribute improvement would increase customer satisfaction?" a satisfaction discriminate analysis was done to discriminate between different levels of customer satisfaction. The average attribute score for one level was compared to that of another level using the *t*-test. Highest *t*-scores indicate the greatest differences. If the component attribute

scores of the factor with highest weight are below the average attribute scores by a large amount, there is a satisfaction problem.

Using the CSI methodology, the following were possible:

- Identifying key factors driving customer satisfaction for bus, heavy rail, and light rail service in the five cities and relative importance of each;
- Constructing customer satisfaction and factor index scores for all cities as well as individual cities;
- Forming a clear understanding of the performance of each transit district relative to the total sample and to other districts; and
- Identifying and prioritizing improvement opportunities for transit operators.

Interesting observations that came out of the survey results for bus service include the following:

- Factors—The two most important factors were “driver” and “system performance.” The factor weights were
    - Driver: 17%
    - System performance: 17%
    - Safety/cleanliness of deboarding area: 15%
    - Safety/cleanliness of waiting area: 13%
    - Vehicle attributes: 11%
    - Vehicle cleanliness: 10%
    - Bus signage and boarding procedures: 9%
    - Shelters at waiting areas: 8%
- Attributes—Each factor is composed of attributes, which were weighted as well. For driver, the following attributes and weights were identified:
    - Driver courtesy: 27%
    - Driver’s competence: 25%
    - Clarity and timeliness of bus stop announcements: 19%
    - Knowledge about system routes and schedules: 18%
    - Personal appearance: 11%
- As customer satisfaction decreased, customer loyalty and recommendations to friends and relatives decreased. Those responding they “definitely” or “probably” would recommend transit service were categorized according to their satisfaction levels:
    - Very satisfied: 97% would recommend service
    - Somewhat satisfied: 85%
    - Neither satisfied nor dissatisfied: 62%
    - Somewhat or very dissatisfied: 32%
- Safety and security issues are closely related to cleanliness issues.

Two of the improvements recommended by the researchers include:

- For good predictive power, a minimum of 200 interviews per mode per city are recommended.
- Open-ended questions regarding reasons for riding transit should be added to the survey.

REVEALED AND STATED PREFERENCE SURVEYS

The revealed preference (RP) survey technique focuses exclusively on the current behavior of the transit customer, while the stated preference (SP) technique uses a survey containing various hypothetical scenarios. SP scenarios typically describe "packages" with varying service and service quality levels and fares. Respondents are asked to choose the preferred package.

Advantages of the SP technique over others, such as RP, include the following:

- Collection of a greater number of datapoints covering a number of potential alternatives, while RP varies only within the limits of existing alternatives;
- Improved identification of willingness to pay for particular service attributes;
- Reduced risk of confounding correlation between attributes; and
- Production of more robust parameters in discrete choice model estimation.

One disadvantage of the SP technique is that it offers hypothetical choices, so the respondents may want to please the interviewer or even the "questionnaire" and provide answers that will evoke a positive response. Some respondents' answers may support their current behavior; while others may desire to affect policy by responding in a certain manner, even though the responses may not reflect their true choices.

The advantages of the SP technique are believed to outweigh its disadvantages, so it has been used in determining mode choice preferences by transportation planners and modelers. Because RP data provide an "anchor" in reality, a combination of SP and RP data is viewed by some researchers to be quite powerful.

The analysis method employs a discrete choice model with a multinomial logit specification. Survey data are input into the model to determine a user preference set that includes service quality attributes as variables. The significance of each variable is expressed in terms of a parameter and a *t*-value.

Recently, a similar method using a combination of the two techniques was used by Prioni and Hensher (*73*) in the creation of a Service Quality Index. To obtain preferred service quality attributes, a set of three "packages" was given to bus passengers, who were asked to select the preferred package. Table 21 provides an example of this.

Table 21. Service Quality Index "Packages" of Transit Service (*73*)

Service Feature	Bus Package A	Bus Package B
Reliability	On Time	10 Minutes Late
One-Way Fare	25% Less than Current Fare	Same as Now
Walking Distance to Bus Stop	10 Minutes More than Now	Same as Now
Waiting Safety	Reasonably Unsafe	Reasonably Unsafe
Travel Time	Same as Now	25% Longer than Current Time
Bus Stop Facilities	Seats Only	Seats Only
Air Conditioning	Available with Surcharge of 20%	Not Available
Info at the Stop	Timetable and Map	None
Frequency	Every 60 Minutes	Every 15 Minutes
Safety on Board	Ride Is Smooth, No Sudden Braking	Ride Is Jerky, Sudden Braking
Cleanliness of Seats	Very Clean	Clean Enough
Ease of Access to Bus	Wide Entry, No Steps	Wide Entry, 2 Steps
Driver Attitude	Friendly Enough	Very Friendly

Each attribute has three levels. For example, the reliability levels are

1. On time,
2. 5 minutes late, and
3. 10 minutes late.

Based on the utility expression derived from the multinomial logit model output, the Service Quality Index is calculated.

STRUCTURAL EQUATION MODELS

Structural equation models may be used to reveal the various relationships among attributes that compose customer satisfaction (*74*). Researchers using these models argue that some attributes may or may not have a direct influence on customer satisfaction. Some attributes may impact another attribute, which, in turn, impacts satisfaction.

A structural equation model consists of multi-level models. A two-level model would have two submodels at each level. Level 1 captures the influence of attributes on each dependent variable, while another generalized attribute incorporates the effects of other attributes. Level 2 represents the effects of the generalized attributes on customer satisfaction (***75***).

$$Y_{ij} = B_{0j} + B_{1j} X_{1ij} + B_{2j} X_{2ij} + \ldots + B_{qij} X_{qij} + r_{ij}$$

where
B_{qj} (q = 0, 1, ..., Q) are Level 1 coefficients;
X_{qij} is the Level 1 predictor q for case i in unit j; and
r_{ij} is the Level 1 random effect, with $N(0,v)$ distribution.

Each of the Level 1 coefficients (B_{qj}) becomes a dependent variable in the Level 2 model:

$$B_{qj} = T_{qo} + T_{q1}W_{1j} + T_{q2}W_{2j} + \ldots + T_{qsq}W_{sqj} + u_{qj}$$

where
T_{qs} are Level 2 coefficients;
W_{sj} is a Level 2 predictor; and
u_{qj} is a Level 2 random effect.

Each Level 1 coefficient may be modeled in Level 2 as one of the following forms (***76***):

1. A fixed Level 1 coefficient: $B_{qj} = T_{qo}$;
2. A non-randomly varying Level 1 coefficient: $B_{qj} = T_{q0} + \sum_{s=1}^{S_0} T_{qs} W_{sj}$;
3. A randomly varying Level 1 coefficient: $B_{qj} = T_{qo} + u_{qj}$; or
4. A Level 1 coefficient with both non-random and random sources of variation: $B_{qj} = T_{q0} + \sum_{s=1}^{S_0} T_{qs} W_{sj} + u_{qj}$.

The advantage of this method is that it breaks down the many drivers of customer satisfaction and reveals the relationships among many levels of variables. This method is more complex than standard regression analysis and can help sort out complicated relationships among variables.

In Stuart et al., the authors use a structural equation model to determine the relationships among variables that affect customer satisfaction. The following results were generated by the model. The first level contains the attributes: safety, courtesy, cleanliness, panhandlers, frequency, predictability, and crowding. The second contains the generalized attributes of security and speed. Security is affected by cleanliness, panhandlers, and frequency. Speed is affected by frequency and predictability. The third level contains the generalized attribute of value and overall satisfaction. Both statistical analysis and conceptual analysis were performed by the authors to construct the model in Figure 15 (***77***).

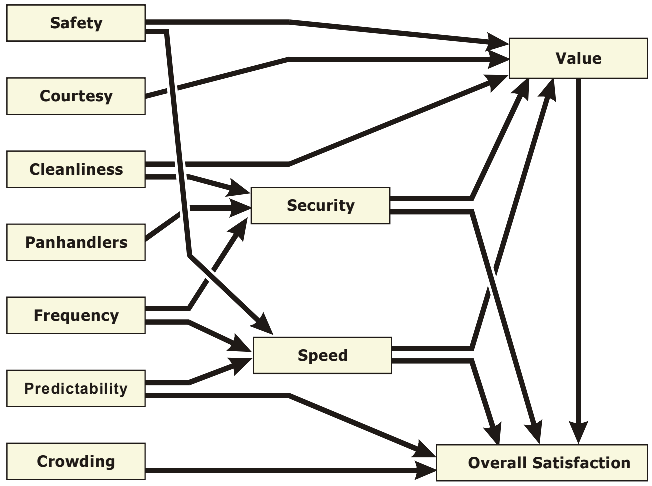

Figure 15. Example Structural Equation Model (77)

The significance of the paths (i.e., relationships between the variables) in Figure 15 is described in Table 22.

Table 22. Example Structural Equation Model Path Statistics (77)

Variables (Independent-Dependent)	Path Coefficient	Standard Error (lower is better)	Critical Ratio (higher is better)
Frequency-Speed	.23	.03	6.64
Predictability-Speed	.25	.03	7.43
Safety-Speed	.28	.03	10.95
Panhandlers-Security	.12	.03	4.05
Frequency-Security	.21	.03	6.50
Cleanliness-Security	.40	.04	11.18
Speed-Value	.32	.04	9.37
Safety-Value	.22	.04	6.14
Security-Value	.11	.03	3.94
Courtesy-Value	.07	.03	2.60
Cleanliness-Value	.12	.03	3.57
Value-Overall Satisfaction	.14	.02	6.41
Speed-Overall Satisfaction	.18	.03	6.32
Security-Overall Satisfaction	.15	.02	7.56
Crowding-Overall Satisfaction	.06	.02	3.40
Predictability-Overall Satisfac.	.34	.03	13.26

SERVQUAL

In market research, customer satisfaction or perceived service quality is viewed by some researchers as a function of customer *expectations* and *perceptions* (*78*). Expectations are predictions of what is likely to happen, and perceptions reflect the service quality that the customer believes he or she has actually experienced. The ServQual instrument is based on this concept of customer satisfaction and was developed to assess customer perceptions of service quality in retail and service organizations. The instrument is in the form of a questionnaire that uses a scale of 0 to 7 (strongly agree to strongly disagree) (*79*).

For example, to assess reliability, the set of questions in Figure 16 would be used.

Expectations:
"My wait time for my bus should never be more than *x* minutes." *or* "Generally, I don't mind if my bus is *x* minutes late."
Perceptions:
"My wait time for my bus is *x* minutes." *or* "Generally, my bus is *x* minutes late."

Figure 16. Example ServQual Question Sets

The difference between customers' perceptions of service quality and their expectations determines their level of satisfaction.

Before the survey can be developed, attributes that define service quality must be identified. Ways in which attributes may be defined are provided in *TCRP Report 47* (***4***) and other literature (***80***, ***81***).

After questionnaires are developed, distributed, and returned, factor analysis is done to verify the construct (i.e., the number of factors that impact perceptions of service quality). The testing of 5, 6, and 7 factors is recommended (***79***). After verification has been completed, the ServQual index may be calculated.

CRITICISM OF SERVQUAL

Opponents of ServQual see quality as a result of customers' perceptions of service quality only. They argue that expectations of information should be excluded from customer satisfaction determination, since the measurement of expectations is difficult. Confirming expectations does not always indicate that customers are satisfied. In some cases, unexpected attributes occur and, hence, there is nothing to judge the perceptions against (***82***).

However, the pervasiveness of ServQual in the service industry may be attributed to the fact that many in the industry believe that expectations do matter and share the view that customer satisfaction is the end product of both expectations and perceptions of service quality.

— APPENDIX B —

PASSENGER ENVIRONMENT SURVEYING

INTRODUCTION

Some transit agencies conduct regular inspections of their facilities and services to make sure that all aspects of transit trip quality meet their customers' expectations. These *passenger environment surveys* (PES) assess a number of qualitative elements, such as *cleanliness,* that are difficult to measure any other way. They can also be used to assess factors that are easily quantified, such as the presence of correct signage, but that cannot be measured by automated means.

While some of the information gathered by passenger environment surveys could be gathered by other means, such as tracking complaints or customer satisfaction surveying, these do not provide the comprehensiveness of a PES. In addition, complaints and customer satisfaction surveys identify what has already gone wrong; a PES can help an agency identify potential customer satisfaction issues before they have a chance to become serious problems.

Several elements are key to having a successful PES program:

- *Assigned professional staff:* Having specific staff members assigned as PES raters provides greater rating consistency day to day and among raters, through greater familiarity with the survey process.
- *Objective rating criteria:* This is the difference between a general description such as "light litter" and a specific definition such as "no more than two pieces of litter smaller than an index card." Objective criteria provide more consistent results and are particularly recommended when PES results are used to evaluate individual and department performance (***53***).
- *Follow-up:* A PES program represents a significant labor investment. To benefit from this investment, an agency needs to have a process in place to identify problem areas and to implement changes designed to resolve the identified problems.

Passenger environment surveying is usually a continual process, with results summarized and reported quarterly.

The following sections briefly describe the PES programs developed by two agencies, MTA-NYCT and the Bay Area Rapid Transit District (BART).

MTA-NYCT EXAMPLE

MTA-NYCT's Passenger Environment Survey is a customer-oriented set of indicators generated quarterly by Operations Planning to measure customer perceptions of the environment in subway stations, subway cars, and buses. PES data are collected during weekday periods between early morning and late evening. PES indicators have been collected and reported for more than a dozen years. Changes in the PES have been made over the years, most recently in 1995 and 2000.

Table 23 provides PES indicators, criteria, and descriptions for subway cars. Table 24 and Table 25 provide similar information for buses and subway stations, respectively.

Table 23. MTA-NYCT PES Indicators: Subway (35)

Indicator	Criteria	Description/Definition
Cleanliness and Appearance	Presence of litter (measured at the terminal)	None, Light, Moderate, or Heavy
	Cleanliness of floors and seats (measured at the terminal)	None, Light, Moderate, or Heavy
	Presence of litter (throughout the day)	None, Light, Moderate, or Heavy
	Cleanliness of floors and seats (throughout the day)	None, Light, Moderate, or Heavy
	Percent cars with no interior graffiti	
	Percent cars with no exterior graffiti	
	Percent cars with no graffiti on windows	
	Percent cars with no broken or cracked windows	
Customer Information	Percent cars with all system maps correct/legible	Cars must have at least two legible/correct maps to comply; minor service changes must be updated within the quarter
	Percent cars with all signage correct	
	Percent cars with public address announcements	Percent of correct announcements versus total potential announcements expected
Functioning Equipment	Percent cars with no broken door panels	
	Lighting conditions in cars	Percent cars with at least 90% of lights on; cars surveyed outside during daylight hours are not rated
	Climate control conditions in cars	Percent cars with average interior temperature between 50°F and 78°F or at least 75% of fans operating when above 78°F
Operations	Percent conductors in proper uniform	

Table 24. MTA-NYCT PES Indicators: Buses (*35*)

Indicator	Criteria	Description/Definition
Cleanliness and Appearance	Presence of litter (measured before entering service)	None, Light, Moderate, or Heavy
	Exterior dirt conditions (measured before entering service)	None, Light, Moderate, or Heavy
	Cleanliness of interiors (measured before entering service)	None, Light, Moderate, or Heavy
	Presence of litter (measured at the terminal while in service)	None, Light, Moderate, or Heavy
	Exterior dirt conditions (measured at the terminal while in service)	None, Light, Moderate, or Heavy
	Cleanliness of interiors (measured at the terminal while in service)	None, Light, Moderate, or Heavy
	Percent cars with no damaged panels	
	Percent cars with no cracked windows	
	Percent cars with no interior graffiti	Includes graffiti on windows
	Percent cars with no exterior graffiti	
Customer Information	Percent buses with readable/correct front sign	Measured 100 feet away
	Percent buses with correct electronic side sign	
	Percent buses with correct rear sign	
	Percent bus announcements that are understandable/correct	
	Percent buses with priority seating stickers	Buses must have at least one legible sticker
	Percent buses displaying a legible/correct bus map	Minor service changes must be updated within the quarter
Functioning Equipment	Climate control conditions in buses	Percent of cars with average interior temperature between 50°F and 78°F except if ambient temperature is above 98°F, when climate control must maintain a 20°F gradient
	Percent buses with operative kneeling feature	
	Percent buses with operative wheelchair lift	
	Percent buses with operating windows	
	Percent buses with operative rear door	
Operations	Percent bus stops where buses board/discharge passengers appropriately	Bus appropriately curbs or kneels
	Percent operators in proper uniform	
	Percent operators properly displaying badges	

Table 25. MTA-NYCT PES Indicators: Stations (*35*)

Indicator	Criteria	Description/Definition
Cleanliness and Appearance	Presence of litter (measured before the morning peak)	None, Light, Moderate, or Heavy
	Cleanliness of floors and seats (measured before the morning peak)	None, Light, Moderate, or Heavy
	Presence of litter (measured after the morning peak)	None, Light, Moderate, or Heavy
	Cleanliness of floors and seats (measured after the morning peak)	None, Light, Moderate, or Heavy
	Presence of graffiti	None, Light, Moderate, or Heavy
Customer Information	Station delay announcements	Percent Understandable/Correct, Percent Partially Understandable Correct, Percent Marginally Understandable/Correct, and Percent Not Understandable/Correct
	Percent stations with legible/correct system maps	At least one map in both paid and unpaid areas; minor service changes must be updated within the quarter
	Percent stations with correct Passenger Information Center	Minor service changes must be updated within the quarter
	Percent Station Control Areas with a correct subway map available	Minor service changes must be updated within the quarter
Functioning Equipment	Percent stations with functional enunciator (where applicable)	Degree of understandability/correctness per delay occurrence
	Percent escalators/elevators in operation	
	Percent station public telephones in working order	Measured by placing a call and/or listening for a dial tone
	Percent station control areas with working booth microphone	
	Percent trash receptacles usable in stations	
	Percent working turnstiles in stations	High entrance and exit turnstiles not included
Operations	Percent booth clerks in proper uniform	
	Percent booth clerks properly displaying badges	

All of the indicators are reported as percentages. For example, litter conditions on buses would be reported as the percent of buses with no litter, the percent with light litter, etc. Litter conditions and floor and seat cleanliness are reported for the system as a whole, as well as for terminals that have cleaning staff (which would be expected to have a higher level of cleanliness) (**52**).

In terms of transferring the New York experience to other agencies, the following issues should be considered:

- The number of indicators is relatively large and may be more than a senior manager can monitor. The number of indicators could be reduced by determining the most important ones that contribute to customer satisfaction for a given agency, or the indicators could be weighted and combined into an index for each group of indicators.
- Customer satisfaction surveys ask respondents to rate various service attributes such as cleanliness. These surveys are subjective, while PES indicators are objective. A comparison between objective measures of the customer experience and subjective measures may determine how closely objective measures are linked to subjective ones and may assist an agency in identifying the PES measures that most correspond with customer perceptions.

BART EXAMPLE

BART's Customer and Performance Research Division is responsible for conducting and reporting results from its Passenger Environment Survey. The PES program is intended to make sure that a high-quality riding environment is provided and that the quality improves over time. Since more than half of BART's passengers have an automobile available at home, BART feels that maintaining this quality is essential to retaining existing choice riders and attracting new riders. Results from the PES program are linked to the evaluations of staff responsible for service quality within the areas measured by the PES program. Because of manager concerns that the PES ratings were too subjective (and thus could unfairly impact a manager's performance evaluation), BART overhauled its PES program in 1997 to provide a greater level of objectivity in ratings (***53***).

BART includes 24 measures in its manual surveys, as listed below. The ten measures shown underlined are considered qualitative and were the ones that the program update addressed. The other fourteen measures are considered more objective, and most can be rated using a yes/no system. The program's categories, and their associated measures are (***53***)

- *Facilities management*: station patio cleanliness, parking lot cleanliness, landscape appearance;
- *Station operations*: station cleanliness, station graffiti, restroom cleanliness, advertising signs in stations, brochures in kiosks;
- *Station agent*: agent available or sign in place, agent in uniform, agent wearing name badge;
- *BART police*: BART police personnel in stations, BART police personnel in parking lots/garages, BART police personnel on trains;
- *Public address announcements*: station arrival announcements, transfer announcements, destination announcements; and
- *Rolling stock*: train exterior graffiti, train doors operative, train interior graffiti, train interior cleanliness, train window etching, temperature on trains, advertising signs on trains.

BART also incorporates the following seven measures into PES reports; however, these measures are recorded automatically, either through maintenance tracking systems or train movement logs (***53***):

- *Elevator/escalator availability*: station elevator availability, escalator availability (street), escalator availability (platform);
- *Fare collection availability*: fare gate availability, ticket vending machine availability; and
- *On-time performance*: train on time, customer on time (considers whether a transfer could be made as scheduled).

The qualitative measures are evaluated using the following process (***53***):

- A section of the station (1,000 square feet) or a train car (one-eighth section of a car) is selected randomly for surveying. The intent of evaluating a sample area, rather than the entire station or car, is to allow raters to perform more careful inspections.
- Points are deducted from a perfect score of 7 for each incidence of a deficiency (up to a maximum of five incidences for any type of deficiency). The minimum possible score is zero. Point values were determined from a group of customers that BART recruited; these values are shown in Table 26.

Table 26. BART PES Deficiency Point Values: Trains (*53*)

Deficiency	**Point Deduction**
Small litter (smaller than an index card)	0.32
Large litter	1.12
Food (visible whole, part smeared or dripped food item)	0.63
Broken glass	1.18
Spills (wet or dry)	0.80
Biohazard	4.23

BART reports PES results in a quarterly report. In the middle of each quarter, confidential reports are given to managers as needed, alerting them to any significant changes (positive or negative) in PES results at that time. The mid-quarter reports give managers more immediate feedback on efforts to improve performance and provide an opportunity to make mid-quarter corrections before the end-of-quarter results are published (***53***).

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