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TCRP G-6
A GUIDEBOOK FOR DEVELOPING A TRANSIT PERFORMANCE-MEASUREMENT SYSTEM

INTERIM REPORT

Prepared for

TRANSIT COOPERATIVE RESEARCH PROGRAM

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ABSTRACT

This report documents the results of Phase 1 of TCRP Project G-6, A Guidebook for Developing a Transit Performance-Measurement System. It presents key characteristics of effective transit performance-measurement systems, drawing from an extensive literature review, interviews with nineteen transit agencies and metropolitan planning organizations (MPOs), and case studies from other service industries. Performance measures commonly used in the transit industry are identified and organized into eight functional groups: availability, service monitoring, community, travel time, safety and security, maintenance and construction, economic, and capacity measures. Gaps in existing transit performance measures are identified, with particular attention paid to community- and customer-focused measures. Special considerations for the use of performance measures in ADA paratransit and other demand-responsive transit systems are discussed. A process for developing a community- and customer-oriented transit-performance measurement system is also presented.

NOTE TO READERS

This report is a companion to *A Guidebook for Developing a Transit Performance-Measurement System*, providing more detailed information—such as the annotated bibliography—than could be included in the Guidebook. This report was originally developed as the project interim report documenting the results of the first half of the TCRP G-6 project. It has been subsequently modified by adding early results from Phase 2 of the project, in particular, specialized case studies of agency performance-measurement programs, but otherwise has not been significantly changed. As a result, some of the information presented in this report also appears in the Guidebook and, in some cases, such as the New York City Transit and SANDAG case studies, the information presented in the Guidebook is more recent, reflecting updates received after the interim report was finalized. Where information appears in both documents, the Guidebook's version should be considered the most up-to-date.

The Background Document is extensively hyperlinked. Links from document references will open the corresponding entry in the annotated bibliography. The bibliography contains a number of links to other related documents available on the Internet at the time the Background Document was developed. Links to material on the Internet were checked at the time this document 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 (or use its search feature, if provided) to find the document.

SUMMARY OF FINDINGS

AGENCY INTERVIEWS

Twenty transit agencies and metropolitan planning organizations (MPOs) were interviewed to learn about their performance-measurement programs. Each agency was asked about the performance measures they use, any standards or targets that were set for these measures, the frequency that the measures are reported, the individuals and groups within the agency that the measures are reported to, successes and challenges with their program, and their opinion of their program's transferability to other agencies. Agencies were also requested to provide the project team with additional documents about their programs, when the documents existed.

Throughout the literature review and the transit agency interviews, one common theme among virtually all transit properties was regularly scheduled performance reporting. Some agencies performed monthly standards reporting, while others preferred quarterly, bi-annual, or annual reporting.

The agencies interviewed used five main ways of developing standards:

1. *Comparing performance 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.
2. *Comparing performance to a baseline average.* 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, with some systems adjusting their baseline values for inflation.
3. *Developing standards internally.* Under this system, transit 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.
4. *Comparing performance to typical industry standards.* The agency surveys other representative agencies, or finds standards in the transit literature, and applies an average or typical standard to their own operations.
5. *Comparing performance to peer agencies.* Under this system, an agency identifies other agencies with similar conditions (e.g., city sizes, level of government support, fare levels, goals and objectives, cost of living indexes, or other similar criteria), and determines how well those agencies are performing in the categories to be measured.

A combination of these approaches would appear to be ideal. Developing a baseline is useful for tracking performance improvements over time. Comparing performance to peer agencies allows one to know which areas one is especially excelling or deficient in. Internal review of standards allows local conditions and objectives to be considered.

Economic performance and service monitoring measures were widely used by the agencies interviewed; safety and security, and maintenance and construction measures were often used; and availability, community, travel time, and capacity measures were rarely used. In contrast, many researchers and organizations have identified the need to address the community and/or customer perspective.

PERFORMANCE MEASUREMENT IN SERVICE INDUSTRIES

While both private sector service companies and transit agencies track revenue-based performance measures, performance measures among Fortune 500 private industry companies are more likely to be driven by measures related to customer satisfaction and customer loyalty. Private service industries are driven by the goal to maintain and increase repeat customer business. Performance measures reported by transit agencies are more likely to be driven by goals oriented to monitoring the system, and goals that change over time. The latter includes measures of service and cost efficiency, such as the number of boardings per hour or per mile, the number of unlinked trips per total vehicle hours, or the accident rate per 100,000 miles.

Only a handful of metropolitan transit agencies have the resources to conduct large-scale market research and customer satisfaction tracking studies on an on-going 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. Critical problems gleaned from customer surveys cannot be conveyed electronically to transit agency front-line personnel for immediate resolution.

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

Specific 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 (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 verbatims)
- Service attributes regarding personnel interactions
    - Courteousness of personnel
    - Timeliness of providing service
    - Quality of information/assistance
    - Resolving problems that arose without unnecessary delay
- Service attributes regarding service efficiency
- Service attribute regarding environment
- Service attributes regarding security and safety
- Service attributes regarding information about the service

- Service attributes about comfort and convenience of use
- Value of the service for costs paid

CHARACTERISTICS OF EFFECTIVE PERFORMANCE-MEASUREMENT SYSTEMS

The following list identifies the key characteristics of effective performance-measurement systems:

- *Stakeholder acceptance*—transit management (especially), agency managers and operational staff, customers, and the agency's governing body must all "buy-in" to the program. When performance measures are used to evaluate a service contractor's performance, the contractor must also be involved.
- *Linkage to agency and community goals*—performance measures are the means of assessing how successful an agency is in accomplishing its goals. Changes in performance, in terms of accomplishing established goals, should be reflected by the chosen measures.
- *Clarity*—performance measures should be readily understood by their intended audience, particularly measures intended to be presented to the public or to decision-making bodies. Graphs and reports must emphasize presentation clarity.
- *Reliability*—users should have confidence in the accuracy of the data used to calculate performance measures, calculation methodologies should remain consistent between reporting periods, and those involved in the performance-measurement process must retain their objectivity.
- *Variety of measures*—a performance-measurement program should reflect a broad range of issues; indicate past, present, and future performance; and include both quantitative and qualitative measures.
- *Number of measures*—the need for a variety of measures must be balanced with the need to avoid having so many measures that users are overwhelmed. Indexes that combine several measures into a single measure can reduce the total number of measures that are reported, but may mask important trends within the index's component measures.
- *Level of detail*—measures should be detailed enough to accurately identify areas where goals are not being accomplished, but should be no more complex than necessary. Different levels of detail may be required at different levels of the organization, but lower-level measures should be consistent with higher-level measures.
- *Flexibility*—a performance-measurement system should provide the flexibility to permit future change, while retaining links to historical measures.
- *Realism of goals and targets*—targets should be realistic, but slightly out of reach, to encourage continual performance improvement. Unrealistic targets will cause the credibility of the program to be questioned. Different service types often serve different goals and will often require different targets, or even different measures.
- *Timeliness*—timely reporting allows all to understand the benefits that resulted from actions to improve service, and allows agencies to quickly identify and react to problem areas.

- *Integration into agency decision-making*—agencies should carefully consider what 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.

Researchers are split on whether employee financial incentives should be tied to performance measure results. There may not be absolute correlation between accomplishments and their related performance measures, and incentive programs may create unintended side-effects, as employees work to meet short-term goals that maximize their individual financial reward, but in a way that hinders long-term organizational performance. The most common areas that are tied to financial incentives are safety, absenteeism, and driver performance (e.g., Roadeos).

GAPS IN EXISTING PERFORMANCE MEASURES

Performance measures used in the transit industry can be organized into eight broad categories:

- availability;
- service monitoring;
- community;
- travel time;
- safety and security;
- maintenance and construction;
- economic; and
- capacity.

In addition, two other categories, paratransit and service contracting, overlap the eight primary categories.

It is not an exaggeration to state that someone at sometime has developed a performance measure for almost anything. The challenge in identifying gaps in existing transit performance measures was not so much in developing new measures. Rather, the challenge was in tracking down performance measures that had not been widely publicized in transit literature, but that could be important components of a transit performance measurement program. A number of less commonly used measures were identified and have been incorporated into the updated performance measure summary that will be included with the Guidebook.

PERFORMANCE MEASURES IN ADA PARATRANSIT AND OTHER DEMAND-RESPONSIVE TRANSIT SYSTEMS

Demand-response service is somewhat different than 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-response service limit or affect growth.
- Demand-response requires a significantly different service delivery approach since individuals' trips must be scheduled and drivers' routes change constantly.
- Improving service quality increases demand for service, but without the economies of scale achievable by other modes (e.g., ridership increases, but the cost per passenger does not decrease significantly).
- Growth in demand often results in significant financial stress for a transit agency, possibly resulting in limiting demand-response service or reducing service levels in other modes.

As a result, applying performance measures to demand-response 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-response environment.

Providing practical and useful transit performance measurements and standards for demand-response service requires an approach that recognizes the significant service differences which exist in demand-response service and seeks a strategy consistent with those differences. Nevertheless, ADA Complementary Paratransit and general demand-response service also have significant areas of similarity with other transit modes.

PROCESS FOR A COMMUNITY- AND CUSTOMER-ORIENTED PERFORMANCE MEASUREMENT PROGRAM

Although a key product of the TCRP G-6 project will be a detailed menu of performance measures that agencies will be able to select from, it is important not to focus on individual measures to the extent that the reasons for implementing a performance-measurement program are forgotten, and the process for applying the measures ignored.

The element that is missing from many existing transit agency performance-measurement programs is not simply that community- and customer-focused measures are rarely included, but something more fundamental: a lack of a clear connection between what is being measured and the agency's goals and objectives. If a transit system sets out to serve its customers and community well, and develops its performance-measurement system around these objectives, appropriate community- and customer-focused measures will naturally be a product of the program.

The key steps in developing a performance-measurement program are as follows:

- *Define the goals and objectives*—two sets of goals and objectives need to be considered: (1) the goals of the performance measurement system—what is it trying to accomplish?—and (2) the agency's overall goals and objectives.
- *Identify users*—potential users of a transit performance-measurement system are managers and staff from different parts of the organization, the agency managers, decision-makers (e.g., a transit board or funding body), and the public. In general, performance measures intended for the public or decision-makers should be relatively simple, easy to understand, and broad; while measures used internally may be more obscure, convoluted, and focused.
- *Identify staff, financial, and equipment constraints*—staff availability, funding constraints, and lack of particular kinds of equipment (e.g., automatic passenger counters, automatic vehicle location systems, or geographic information systems) can limit the kinds of measures an agency realistically use. However, agencies should develop a set of ideal measures that best match their goals and objectives, even if they must settle for interim surrogate measures.
- *Select appropriate performance measures*—establish the general, overarching categories to measure first, and then select appropriate, user-specific measures within those categories. Next, consider how frequently each measure should be tracked and reported. Finally, establish realistic, but challenging targets for each measure. Different standards may be needed for different types of services and for different times of the day.
- *Develop consensus on the measures*—a transit system should make a concerted effort to develop consensus on the major aspects of the performance-measurement system among the key stakeholders involved.
- *Assign staff responsibilities*—each component of the performance-measurement program must be assigned to specific staff members or positions, with data collection, data analysis, and data reporting being the primary responsibilities.
- *Implement data collection and analysis procedures*—performance standards are only as good as the agency's data collection capabilities. Technological improvements can substantially increase an agency's ability to collect information and monitor systemwide performance, but can also generate a potentially overwhelming amount of data.
- *Conduct a pilot test*—it is prudent to conduct a small-scale pilot test of the program to make sure that everything is working as intended. Potential problems can be identified and corrected prior to proceeding to a systemwide deployment of the program.
- *Monitor and report performance*—regular reporting is essential; a performance-measurement program that includes a diverse set of measures may require different reporting periods for different groups of measures.
- *Take corrective actions as needed*—perhaps the most important step in the process, this step considers the performance that has been measured, identifies particular aspects of performance that require action, identifies a way to accomplish the desired performance improvement, and, finally, implements that corrective action. The impacts of the corrective action are subsequently tracked.

- *Periodically review the program*—agencies should periodically review the overall program performance to make sure it is working as intended. Standards are particularly important to review in order to avoid institutional complacency—if standards are being met, they should be revised upwards to encourage continued improvement, as long as the new targets are realistic and the benefits achieved will outweigh the costs of achieving the higher performance level.
- *Periodically review goals and objectives*—as part of the agency planning process, every five years or so, the agency should reconsider both their own priorities and the community's priorities, and reorganize their goals and objectives accordingly. If the agency goals and objectives undergo a significant overhaul, it is possible that the performance-measurement program may require the same.

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1. INTRODUCTION

RESEARCH PROBLEM STATEMENT

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 is 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.

The objective of this research is to produce a practical, user-friendly Guidebook that will 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 will provide a menu of performance indicators and measures, describe how to select and implement the most appropriate performance indicators and measures, and explain how to incorporate the indicators and measures in the decision-making process to monitor and improve service.

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2. FINDINGS

SUMMARY OF PHASE 1 AGENCY INTERVIEWS

A total of 20 transit agencies, metropolitan planning organizations (MPOs), and regional authorities were interviewed by project team members to learn about their performance measurement programs. Each agency was asked about the performance measures they use, any standards or targets that were set for these measures, the frequency that the measures are reported, the individuals and groups within the agency that the measures are reported to, successes and challenges with their program, and their opinion of their program's transferability to other systems.

The agencies interviewed consist of:

- Albany, NY: Capital District Transportation Authority
- Baltimore, MD: CitiStat
- Baltimore, MD: Mass Transit Administration
- Champaign-Urbana, IL: Champaign-Urbana Mass Transit District
- Chicago, IL: Chicago Transit Authority
- Chicago, IL: Regional Transportation Authority
- Columbus, OH: Central Ohio Transit Authority
- Denver, CO: Regional Transportation District
- Hong Kong, China: Kowloon-Canton Railway Corporation
- Houston, TX: Houston Metro
- Livermore, CA: Livermore Amador Valley Transit Authority (LAVTA)
- Los Angeles, CA: Los Angeles County MTA
- Miami, FL: Miami-Dade Transit
- Nashville, TN: Nashville Metro Transit Authority
- New South Wales, Australia: State Transit
- New York, NY: MTA-New York City Transit
- Oshkosh, WI: Oshkosh Transit System
- Portland, OR: Tri-Met
- San Antonio, TX: VIA Transit
- San Diego, CA: San Diego Association of Governments
- San Diego, CA: Metropolitan Transportation Development Board

The results of each interview are summarized below, and include the name(s) and position(s) of the persons interviewed at each agency. A summary of measures most commonly used by these agencies appears following the individual agency summaries. Agencies were requested to provide the project team with additional documents about their programs, where they existed.

Albany, NY: Capital District Transportation Authority

Contact Person: Jack Reilly, Deputy Director, Director of Planning and Development
Size of Agency: Medium
Transit Modes: Bus, demand-responsive
Years Performance Measurement Program was Initiated/Most Recently Updated: The measurement program was implemented about 12 years ago by the planning staff at CDTA

System Profile

CDTA was formed in 1970 by the New York state legislature. The agency's mission is "to transport customers safely and reliably at reasonable cost." CDTA maintains a fleet of approximately 226 vehicles, 25 of which are demand-responsive paratransit vehicles used for the Special Transit Available by Request (STAR) program. CDTA's service area covers approximately 2,300 square miles and includes four counties and the cities of Albany, Schenectady, and Troy. In 2000, 11.4 million unlinked passenger trips were completed on CDTA buses and 96,000 were completed on STAR.

Measures Used and Standards/Targets

The primary performance measure used by the Capital District Transportation Authority (CDTA) is passengers per hour at the route level. CDTA does not have a standard for this measure. Other measures such as cost per passenger and on-time performance are looked at from time to time, but are not considered on a systematic basis and are usually reviewed when a problem occurs.

Data Collection Procedure

Data collection efforts are handled by the information technology group. The information technology group obtains the data from the field from bus operators, using farebox information. The biggest concern is data integrity.

APC equipment has been installed on some of CDTA's buses. Also, AVL equipment will be installed. Hence, in the near future, the likelihood that CDTA will be collecting schedule adherence and other statistics on a more systematic basis is high.

Monitoring and Reporting

The passengers per hour performance measure is incorporated into decision-making when there is a large change. Typically, CDTA does not experience large shifts in factors such as population and land use that would cause a big change in ridership.

Cost per passenger and on-time performance are usually reviewed when a problem occurs.

Successes and Challenges with the Performance Measurement Program

Bus operators had to be trained to use and record farebox information correctly.

Baltimore, MD: CitiStat

Program Profile

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:

- Accurate and Timely Intelligence
- Effective Tactics and Strategies
- Rapid Deployment of Resources
- Relentless Follow-Up and Assessment

The following sections present two viewpoints on the CitiStat system, the first from a city department that collects agency-specific data and is accountable for its results, the second from an overall City Hall perspective of how the system is applied.

Office of Transportation Summary

Contact Person: Mr. Al Foxx, Director, Office of Transportation
Year Program was Initiated: March 2000

Goals and Objectives of the Program

The CitiStat program was implemented 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 Used and Standards/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, then 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 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 are reported to CitiStat, but there are no direct polls.

Monitoring and Reporting

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

Successes and Challenges with the Program

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.

Transferability of Program to Other Cities/Regions

The CitiStat program is transferable.

City Hall Interview Summary

Year Program was Initiated: The first departments started reporting June 29, 2000; the transportation office began reporting in October 2000.

Goals and Objectives of the Program

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, it is impossible to make changes.

Measures Used and Standards/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 web site at http://www.ci.baltimore.md.us/news/citistat/. There are several measures such as budget and personnel measures 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 mange 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 with random 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 with the Program

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 didn't 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 of Program to Other Cities/Regions

The program is very transferable to other regions/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 other jurisdictions who have come to Baltimore to view the system in action.

Baltimore, MD: Mass Transit Administration

Contact Person: Simon Taylor, Manager of Service Development and Commuter Bus Operations
Size of Agency: Large
Transit Modes: Bus, heavy rail, commuter rail, light rail, ADA paratransit

System Profile

The MTA is one of five agencies within the Maryland Department of Transportation. MTA's mission is to provide "a network of transit and rail freight services … throughout Maryland in a safe, reliable, and efficient manner that supports the economy and the environment." To that end, MTA maintains a fleet of approximately 900 buses, 100 heavy rail vehicles, 150 commuter rail vehicles, and 50 light rail vehicles, as well as demand-responsive vehicles. In 2000, MTA provided approximately 87 million unlinked bus trips, 13.5 million unlinked heavy rail trips, 5.5 million unlinked commuter rail trips, and 8.5 million unlinked light rail trips.

Measures Used and Standards/Targets

The following four performance measures are applied:

- Boardings per mile
- Boardings per trip
- Subsidy per boarding
- Farebox recovery ratio

For the commuter bus services (premium, express services over longer distances), the boardings per mile measure is not applied. Each route is scored as either "successful," "acceptable," or "problem," with the score based on an average of the 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% fare box recovery ratio
- Less than $0.60 subsidy per boarding

Problem:

- Less than 1.6 boardings per mile
- Less than 20 boardings per trip
- Less than 30% fare box recovery ratio
- Greater than $1.20 subsidy per boarding

"Acceptable" consists of values between the listed values above.

Data Collection Procedure
MTA's Marketing Department conducts annual phone surveys to a random sample of the population in its service area to assess traveler characteristics and attitudes toward MTA service. MTA Service Planning conducts route-specific on-board surveys when there are perceived or documented problems with route performance.

Monitoring and Reporting
MTA prepares a Monthly Service Performance Report to assess route performance on its core bus (City of Baltimore and Anne Arundel County), commuter bus (other areas in state), and Baltimore LRT and heavy rail lines. The Monthly Service Performance Report uses the same measures as the Annual Report to assess route performance.

Transferability of Performance Measurement Program to Other Transit Systems
MTA feels that its performance measurement system, at least the threshold levels separating successful, acceptable, and problem service, would not be transferable to other transit systems, due to the particular characteristics of MTA service and reporting.

Champaign-Urbana, IL: Champaign-Urbana Mass Transit District
Contact Person: William Volk, General Manager
Size of Agency: Small
Transit Modes: Bus, ADA paratransit
Years Performance Measurement Program was Initiated/Most Recently Updated: The last time the agency reviewed its performance measures was 1995, although CUMTA's current performance measurement policy was approved by the board in 2000.

System Profile
CUMTA was formed by referendum in 1970. The agency operates a fleet of approximately 90 buses and 15 demand-responsive vehicles and carries approximately nine million passengers per year.

Goals and Objectives of the Performance Measurement Program
CUMTA uses its performance measurement system to evaluate the effectiveness of its route planning and overall system performance. Performance measures have been an integral part in helping to tailor service to meet transit market demand, allowing for CUMTA to determine appropriate matches between service levels and demand.

Measures Used and Standards/Targets

CUMTA's performance standards are based on a single set of empirical averages for each measure that were established in a recent strategic plan. If a route is performing at 50% above or below the average, staff is required to analyze and recommend improvements to the service to bring the standard closer to the desired level. This service re-evaluation takes place on a quarterly basis.

CUMTA uses the following measures:

- Passengers
- Revenue Hours
- Passengers Per Revenue Hour

Data Collection Procedure

The agency's measurements are made by the staff on both system-wide and route-specific scales, three times per year. Origin-Destination studies are conducted every two years. The agency is currently installing Automatic Passenger Counting (APC) devices on board system buses to aid in the data collection process.

CUMTA measures "softer" community indicators through complaint measures and satisfaction surveys. It was felt that the softer data were more difficult to collect than the more traditional transit operating statistics. Complaint measures are used as indicators, as is talking with drivers, doing vehicle inspections, etc. CUMTA does not have procedures in place for tracking these more qualitative performance measures.

Monitoring and Reporting

Management is required to submit performance reports to the board. The data collected are used to compare the Champaign-Urbana system with peer transit systems to evaluate the quality of their service. CUMTA is not required to submit performance reports as a means of qualifying for various funding sources. On the whole, CUMTA is satisfied with its performance measurement program and was hopeful that the APC technology would improve its monitoring and reporting capabilities.

Successes and Challenges with the Performance Measurement Program

For a small transit system, CUMTA's performance measurement program is adequate for providing useful information to aid management in the decision making process. CUMTA's current performance measurement policy does not differentiate between route or service type. This "one size fits all" approach is problematic since the system's routes have considerably different operating and service characteristics. At the very least, CUMTA should differentiate its performance standards for university and non-university services due to the very distinct differences between these service types.

Transferability of Performance Measurement Program to Other Transit Systems

CUMTA's performance measurement program could be transferred to another transit system with similar characteristics, "particularly where the services are more uniform." However, the value of transferring elements of this program may not be all that significant as compared to elements from more innovative performance measurement programs.

Chicago, IL: Chicago Transit Authority

Contact Person: Bill Mooney, Vice President of Rail Operations
Size of Agency: Large
Transit Modes: Bus, heavy rail, ADA paratransit, etc.
Years Performance Measurement Program was Initiated/Most Recently Updated: 1992/Updated every year

System Profile

CTA began operating in 1947 and is now one of the largest transit systems in the U.S. Its service area includes Chicago and 38 suburbs. In 2000, CTA provided approximately 302 million unlinked bus trips, 176 million unlinked heavy rail trips, and 1.2 million unlinked paratransit trips. CTA's fleet includes approximately 1,900 buses and 1,200 rail vehicles, as well as approximately 590 demand-responsive vehicles available through contracted carriers. CTA is governed by a seven-member board appointed by the mayor of Chicago and the governor of Illinois.

Goals and Objectives of the Performance Measurement Program

CTA's performance measurement program was originally conceived because it was considered to be a good management practice and the program was not a legislative mandate. CTA is pleased with the effectiveness of the performance measurement program and believes that it has become an absolute necessity for the functionality of the transit system. Overall, CTA is attempting to provide a better product with fewer resources, and the performance measurement program is one technique that assists CTA in achieving this goal.

Measures Used and Standards/Targets

The rail division utilizes approximately 150 performance indicators. Following is a representative list of some of the primary performance standards utilized by CTA's rail operations division:

- *exterior car wash performance* — goal is to wash cars every 14 days
- *interior car cleaning performance* — goal is for 98% of rail cars to be clean and swept
- *on-time performance* — goal is to keep delay under 4 minutes. CTA keeps track of trains running more than 4 minutes late by time of day, by line, and whether train is express/local. CTA also keeps track of the reason for the delay.
- *staff attendance* — CTA attempts to have an absenteeism rate no greater than 3-7%.
- *overtime hours worked* — CTA has specific overtime requirements/goals for its transportation/vehicle maintenance departments, not to exceed 6,000 hours per month.
- *accident rate per 100,000 miles* — goal for traffic/passenger accidents per 100,000 miles operated is 0.12
- *mean mileage between reported defects* — CTA has different goals for different rail lines, but the range goes from 1,500 miles to 7,500 miles.
- *annulled trips* — the 2001 goal for purple/red/yellow lines is 50 annulled trips or less (trips scheduled but not made)

Data Collection Procedure

Performance standards are collected at least monthly and in some cases, more frequently, such as on-time performance. CTA staff collects all performance measures internally since very little service is actually contracted out to a private operator. As a means of evaluating customer satisfaction with the system's rail service, CTA conducts an annual on-board passenger survey. Many of the same questions are asked each year, which enables CTA to monitor customer satisfaction over a period of time. CTA relies heavily upon this survey effort to determine which service changes were noticed by its passengers. CTA uses this data to identify system improvements for the next year. CTA indicated that they probably do a better job collecting data for the standards in the maintenance categories than the more traditional performance standards such as on-time performance.

Monitoring and Reporting

Each year, CTA completes a system-wide executive summary on the performance measurement program. Additionally, route-specific performance measurement reporting is also practiced by CTA's rail division on a monthly basis. CTA considers the performance measurement data to be particularly useful to evaluate the system's performance over time. In the last couple years, CTA has begun using the performance measurement program as an incentive program tied to system performance. Contracts are written to hold CTA employees accountable for the service provided. In summary, CTA's performance measurement program primarily effects service changes and employee compensation.

Successes and Challenges with the Performance Measurement Program

CTA's performance measurement program appears to have been particularly useful for the transit system's rail division by providing the system with better information by which overall performance can be improved. Cleanliness, for instance, has improved substantially on CTA rail cars since specific cleanliness performance measures were adopted. One of the program's strengths is that CTA has specific targets for most performance standards. This provides the system with a benchmark by which to evaluate its performance in each functional area. For example, CTA attempts to sweep the interior of 100% of rail cars every evening. At the end of the day, it is fairly easy for CTA to make a determination of whether they have met the target goal for each performance measure.

In the near future, CTA plans to automate data collection efforts so that the transit system has access to information in a more timely manner, since this has been the largest challenge in CTA's performance measurement program.

Transferability of Performance Measurement Program to Other Transit Systems

CTA's performance measurement program is a good model for larger transit systems with the resources to collect, report, and evaluate information relating to the system's performance in a myriad of categories.

Chicago, IL: Regional Transportation Authority

Contact Person: Mark Pitstick, Manager, Program Support
Size of Agency: Large
Transit Modes: Bus, heavy rail, commuter rail

System Profile

Chicago RTA was formed in 1974 and oversees CTA, Metra commuter rail, and Pace suburban bus. CTA was interviewed and profiled separately. Metra maintains approximately 1,100 rail vehicles and, in 2000, provided over 72 million unlinked trips. Pace maintains approximately 740 buses, 240 demand-responsive vehicles, and 440 vans for its vanpooling program. In 2000, Pace provided approximately 36 million unlinked bus trips, 1 million unlinked paratransit trips, and 1 million unlinked vanpool trips.

Goals and Objectives of the Performance Measurement Program

When RTA was initially created in 1974, it was responsible for regional transit service planning and at that time had a set of transit service standards and performance measures. In the early 1990s, the agency's mission changed to that of only coordinating regional transit funding allocation, and hence it terminated its detailed reporting system.

RTA is very interested in having a consolidated regional performance measure system again developed for the Chicago area—at least a system that can combine modes to conduct sub-regional assessments--and potentially incorporating the transit quality of service framework identified in the Transit Capacity and Quality of Service Manual. A quality of service assessment was conducted in 2000 in the Chicago area associated with the TCRP A-15A project.

Measures Used and Standards/Targets

Measurement categories include cost effectiveness, cost efficiency, and service effectiveness. Standard reporting measures in each of these categories include the following:

- Cost effectiveness: Operating expense per passenger mile
- Cost efficiency: Operating expense per total vehicle mile
- Service effectiveness: Unlinked trips per total vehicle hours

With respect to the three service boards, CTA recently updated its Service Standards, and Pace is in the process of updating standards last modified ten years ago. Metra's primary service performance measure is to provide 95% on-time performance in the peak direction, with service at least every 20 minutes.

Monitoring and Reporting

In recent years, the RTA has focused on publishing an annual peer review report, comparing the operations of the three transit service boards in the Chicago area: the Chicago Transit Authority (rapid transit and bus), Pace (suburban bus), and METRA (commuter rail). The last report was prepared two years ago. The report compared these Chicago-area systems to similar systems in other urban areas in the U.S.

Successes and Challenges with the Performance Measurement Program

As mentioned previously, the RTA is interested in having a consolidated regional performance measure system again developed for the Chicago area—at least a system that can combine modes to conduct sub-regional assessments—and potentially incorporating the transit quality of service framework identified in the Transit Capacity and Quality of Service Manual.

Columbus, OH: Central Ohio Transit Authority

Contact Person: Nicolas D'Orsi, Director of Organizational Performance
Size of Agency: Large
Transit Modes: Bus, ADA Complementary Paratransit

System Profile

COTA provides 65,000 daily bus rides and 500 daily rides on Project Mainstream, COTA's service for people with disabilities who cannot use fixed-route service. With a fleet of 350 buses, COTA travels throughout Franklin County on 70 routes, with 5,500 bus stops, 373 bus shelters, 24 park & rides, and over 1 million calls annually to the customer information center.

COTA began providing service in Franklin County on January 1, 1974. A 13-member board of trustees oversees the transit system and Ronald L. Barnes serves as president/CEO. In November 1999, Franklin County voters approved a 0.25 percent permanent sales tax for COTA–the first time for permanent funding in COTA history.

Goals and Objectives of the Performance Measurement Program

Consistent with furthering COTA's mission, "to provide customer-focused mobility solutions for Central Ohio communities through strategic partnerships, innovative planning, and implementation options"

Measures Used and Standards/Targets

COTA Performance Measures

- Total Ridership, Annual — Quarterly
- Passengers Per Hour — Quarterly
- Subsidy or Cost Per Passenger — Quarterly
- Farebox Recovery Ratio — Quarterly
- Cost per Vehicle Hour — Quarterly
- Pay-to-Platform Hours — Quarterly

Target performance levels are established by internal Finance Department and Executive Management Team.

Performance Standards

- Total Ridership Annual — Monthly Standard set by COTA President
- On-Time Performance — Monthly Standard set by COTA President
- Vehicle Accidents per *x* Miles — Monthly Standard set by COTA President
- Road Calls per *x* Miles — Monthly Standard set by COTA President
- Pay-to-Platform Hours — Monthly Standard set by COTA President
- Passenger Complaints per *x* Hours/Miles — Monthly Standard set by COTA President

Community-based Standards

	Board/Governing	Citizen Groups	Internal Staff
Complaints and Compliments	☒	☐	☐
Percentage of Accessible Vehicles	☐	☐	☒

Monitoring and Reporting

Performance measures are reported quarterly to the COTA Board of Directors, which is composed of individuals appointed by the City of Columbus, Franklin County, and suburban cities that are part of COTA's service area. COTA's Finance Department and the Executive Management Team establish target levels for these measures.

Successes and Challenges with the Performance Measurement Program

COTA has found that the overall number of complaints has decreased over time as COTA has made changes based on information captured in the performance measurements. However, COTA also sees room for improvement: performance measures currently being tracked are based on existing available resources, and there is a need to "create quality reports and not just data."

Transferability of Performance Measurement Program to Other Transit Systems

Programs would be transferable to other agencies.

Denver, CO: Regional Transportation District

Size of Agency: Large
Transit Modes: Bus, light rail, ADA paratransit
Years Performance Measurement Program was Initiated/Most Recently Updated: Reviewed every three years

System Profile

The Colorado state legislature created the Regional Transportation District (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 Used and Standards/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 safety (e.g., 1 vehicle accident ratio 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 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 once a year, covering one to two service classes. Several evaluation categories relate to the degree of satisfaction of the customer. 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 with the Performance Measurement Program

In the opinion of RTD staff, the performance measure system works fine. The Quarterly Progress Report measures are more frequent and tend to be more visible to the public and media. RTD is looking forward to receiving the new Guidebook on Developing a Performance-Measurement System as part of the TCRP G-6 project--the interviewee is on the project panel--to help guide how changes in their system might be made. RTD is very positive toward performance measurement in general, to help the agency effectively make service and operational decisions.

Transferability of Performance Measurement Program to Other Transit Systems

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

Hong Kong, China: Kowloon-Canton Railway Corporation

Contact Person: Dr. Lok Kee Siu, New Technology and Systems Planning Manager
Transit Modes: Heavy rail, light rail

System Profile

The Kowloon-Canton Railway Corporation (KCR) has two main operating divisions:

- KCR East Rail, which carried 800,000 passengers per day in 2000, links Hong Kong with Mainland China and also serves the New Territories within Hong Kong.
- KCR Light Rail, operating in the North West New Territories, is 32 kilometers long, has 57 stops, and carried 320,000 passengers per day in 2000; some bus services are also run in conjunction with light rail services.

KCR's mission is "to provide a safe, reliable, profitable, and integrated railway network meeting the increasing demand for territorial, cross-boundary, and intercity railway services."

Measures Used and Standards/Targets

KCR publishes separate targets for its two operations, as well as the performance measures achieved in the previous year. Tables 1-3 reflect performance and targets for 2000.

Table 1. KCR 2000 Performance and Targets - Light Rail (2000)

Performance Measure	Target	Actual Performance (2000)
Service delivery	99%	99.9%
Punctuality	99%	99.39%
Service reliability: kilometers run per failure	> 80,000	89,300
Service reliability: time affected by failure	< 35 mins.	19.07 mins.
Availability of ticket vending machines	99%	99.86%
Availability of Octopus equipment (smart cards)	99%	99.97%
Cleanliness: inside cleaned daily	99%	100%
Cleanliness: outside cleaned every two days	99%	100%
Cleanliness: Platform cleaned daily	99%	100%
Number of service disruptions over 20 minutes	Minimal	1
Passengers/public injured per million passengers carried	Minimal	0.23
Response to phone inquiries (within 2 working days)	99%	100%
Response to letter inquiries (within 6 working days)	99%	100%

Table 2. KCR 2000 Performance and Targets - Bus Services (2000)

Performance Measure	Target	Actual Performance (2000)
Service delivery	99%	99.29%
Service reliability: kilometers run per failure	> 65,000	90,400
Cleanliness: inside cleaned daily	99%	100%
Cleanliness: outside cleaned daily	99%	100%

Table 3. KCR 2000 Performance and Targets - East Rail (2000)

Performance Measure	Target	Actual Performance (2000)
Service delivery	99%	99.9%
Punctuality	99%	99.6%
Availability of ticket vending machines	99%	99.6%
Availability of train information displays	99%	100%
Availability of add value machines	99%	99.8%
Availability of enquiry processors	99%	100%
Availability of first class processors	99%	100%
Availability of fare collection gates	99%	99.9%
Availability of escalators	99%	99.9%
Cleanliness: external train washing	99%	99.6%
No. service disruption over 20 mins. (p.a.)	Minimal	4
On-train air-conditioning failures per month	< 3	2.5
Response to phone inquiries (within 2 working days)	99%	100%
Response to letter inquiries (within 6 working days)	99%	100%

Houston, TX: Houston METRO

Contact Person: Howard Plotkin, Senior Analyst, Office of Management and Budget
Size of Agency: Large
Transit Modes: Fixed-route service, HOV lanes, vanpool service, ADA paratransit. Light rail service in Houston is scheduled to begin in 2004.

System Profile

Houston METRO operates a service of approximately 1,400 buses, and 118 vans that are part of the MTA's METROlift ADA Complementary Paratransit service. METRO's bus system serves approximately 2,650 service miles. During 1999, METRO provided more than 101 million unlinked passenger trips. This meant than on an average weekday METRO provided more than 332,000 passenger trips. METRO's routes extensively cover the heart of downtown Houston and stretch into far-reaching suburbs.

METRO was created in 1978 by Houston voters and a one-cent sales tax to support its operation over 1,285 square miles. A nine-member Board of Directors representing Houston, Harris County and 14 member cities, governs the agency.

Goals and Objectives of the Performance Measurement Program

Performance consistent with mission statement: "…to provide the safest, highest quality services and mobility solutions that exceed our customer's expectations while creating economic growth."

Measures Used and Standards/Targets
Ridership standards are as follows:

• On-time performance	85.5% of all trips
• Vehicle accidents per 100,000 Miles	1.15
• Cost per passenger	$2.08 per passenger
• Fare recovery ratio	20.3 % of total cost
• Cost per vehicle mile	$4.57 per vehicle mile
• Percentage of accessible vehicles	100%
• Passenger complaints per 100,000 boarding	17.0
• Vehicle miles between service interruptions	5,000
• Cost per passenger mile	$0.42
• Subsidy per passenger mile	$0.33

Monitoring and Reporting
Performance measures reported to the Board include:

- Ridership – annually
- Cost per passenger – annually
- Subsidy per passenger mile – monthly and annually
- On-time performance – monthly and annually
- Subsidy per passenger – monthly and annually
- Farebox recovery ratio – monthly and annually
- Cost per vehicle mile – monthly and annually
- Passenger complaints per 100,000 boardings – monthly and annually
- Percent of accessible vehicles – annually
- Vehicle miles between service interruptions – monthly and annually
- Major security issues per 100,000 Boardings – monthly and annually. "Major" issues consist of the following crimes: homicide, forcible rape, robbery, aggravated assault, burglary, larceny/theft, motor vehicle theft, and arson.

Community-related standards are not explicitly used, but the following are reported. These are also reported on an annual basis and include:

- On-time performance
- Complaints and compliments
- Percentage of accessible vehicles

Successes and Challenges with the Performance Measurement Program
Competition among the different bus operating facilities designed to reduce the level of bus accidents has fostered an increased emphasis upon safety.

Reporting standards have the challenge of deciding on which definition to use: should it be vehicle miles or revenue miles? vehicle hours or revenue hours?

Transferability of Performance Measurement Program to Other Transit Systems
Can be transferred to other systems

Livermore, CA: Livermore Amador Valley Transit Authority

Size of Agency: Small
Transit Modes: Bus, ADA Paratransit
Years Performance Measurement Program was Initiated/Most Recently Updated: 1998/yearly

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 the Alameda County supervisor.

Goals and Objectives of the Performance Measurement Program

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 Used and Standards/Targets

The system uses a total of nine performance measures, listed below. Its measures are currently only systemwide, but they intend to develop a system profile manual soon to create route by route evaluations. Currently, the system 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 routes:

- 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 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 figure out what is going on. 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 with the Performance Measurement Program

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. Future plans intend to extend performance to a route-by-route level of analysis. Overall, LAVTA felt that when considering the general usefulness of performance measures programs, "it is vital to compare apples to apples and oranges to oranges." In other words, it is potentially dangerous to try to compare things that may be numerically similar but actually quite different in reality.

Transferability of Performance Measurement Program to Other Transit Systems

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.

Los Angeles, CA: Los Angeles County MTA

Contact Person: Jake Satin-Jacobs, Chief Administrative Analyst, Transit Operations Support
Size of Agency: Large
Transit Modes: Bus, heavy rail, light rail

System Profile

MTA was created by the California state legislature in 1992 through a merger of the Los Angeles County Transportation Commission and the Southern California Rapid Transit District. MTA's mission is "the continuous improvement of an efficient and effective transportation system for Los Angeles County." The agency operates a fleet of approximately 2,400 buses, 100 heavy rail vehicles, and 70 light rail vehicles. In 2000, MTA provided approximately 360 million unlinked bus trips, 28 million unlinked heavy rail trips, and 30 million unlinked light rail trips. MTA is governed by a 13-member board. ADA paratransit service is provided by Access Services, Inc., an agency established by the transit operators in Los Angeles County.

Measures Used and Standards/Targets

Until 1996, formal performance reporting has been limited; however, performance measurement has been a part of operations for many years. The monthly and weekly reports have been generated in the present format for the past five years. The "How You Doin'?" performance incentive program was established recently, on January 1st, 2001. The "How You Doin'?" program has separate criteria for bus and rail and, within bus, it is divided into transportation and maintenance functions. The measures in the program are:

- On-time pullout performance (both bus functions)

- In-service on-time performance (bus transportation function)
- Customer complaints (bus transportation function)
- New workers compensation claims (bus transportation function)
- Accidents (bus transportation function)
- Miles between road calls (bus maintenance function)
- Past due preventive maintenance (bus maintenance function)
- Workers compensation claims and attendance (bus maintenance function)
- Wayside maintenance (rail)
- Vehicle availability (rail)
- Operator attendance (rail)
- Schedule adherence (rail)

Monitoring and Reporting

LACMTA issues two performance reports on a regular basis: one weekly, and the other monthly. The weekly report is provided to all appropriate parties on a timely basis (it is generated on Wednesday for the week ending the prior Saturday.) The two reports contain many overlapping indicators. Once released, the monthly report becomes a public document. LACMTA also operates a performance-based incentive program, "How You Doin'?". The program ranks bus divisions (or yards) based on their performance and gives monetary awards for best and most improved performance.

The interviewee reports that "executive management lives and breathes by the reports" and "what gets measured, gets attention." If for some reason a report is late, managers contact his department to inquire about it. In fact, the results of the reports are a part of decision making and operations—they are incorporated in "Management Action Plans, Strategic Plans, and literally everything in Operations."

Successes and Challenges with the Performance Measurement Program

The interviewee stated that the performance measures programs have been successful and have received considerable focus and attention of LACMTA staff and managers.

The primary obstacle in establishing the performance measurement reports was data acquisition. The "owners" of data were protective of it and did not wish to share it. Months were spent negotiating for the release of the data. Before these regular weekly and monthly reports had been established, it seemed that performance reports came and went because they were not distributed to the same persons at the same times on a consistent basis.

Miami, FL: Miami-Dade Transit

Contact Person: Bob Piersall, Manager of Service Planning and Monitoring
Size of Agency: Large
Transit Modes: Bus, heavy rail, automated guideway, ADA paratransit
Years Performance Measurement Program was Initiated/Most Recently Updated: The Service Planning Guidelines were last updated in January 1998.

System Profile

MDT is the largest transit system in Florida. It was created in 1960 by the Dade County Commission. MDT's Metrobus fleet includes 580 buses, 45 minibuses, and 17 vans, which were used to provide almost 66 million unlinked trips in 2000. The Metrorail fleet includes 136 cars, and it provided approximate 14 million unlinked trips in 2000. Metromover, an automated guideway transit service with 29 units, provided approximately 4 million unlinked trips in 2000.

Goals and Objectives of the Performance Measurement Program

MDTA has the following reports involving transit service performance measures and standards:

- Service Planning Guidelines
- Monthly Report – Ridership Technical Report
- Quarterly Performance Report
- Annual Report

The Service Planning Guidelines are just that: guidelines, not standards. In the opinion of the person interviewed, "political" considerations come into play too often in service implementation decisions for the guidelines to be effective. The Service Planning Guidelines are route-specific, with routes compared to similar types of service. The guidelines address the following:

- Passenger loading (less than 175%)
- Route design
- Route spacing
- Directness of travel
- Bus stop spacing
- Frequency/span of service

Existing service is evaluated on the following measures:

- Less than ½ system boardings per revenue mile
- No more than twice the system cost per boarding

Measures Used and Standards/Targets

For the Quarterly Report (prepared by MDTA's Management Services Group), the following performance measures are used, applied at the system level:

- Weekly boardings
- Schedule adherence (bus vs. rail) – random sample of trips, 500 per month – also representative days during month – supervisors collect data, with 0-5 minutes late being considered on-time for bus, 0-3 minutes late considered on-time for rail
- Number of passenger complaints – paratransit separated from fixed-route service
- Average miles per mechanical road call – for fixed-route bus
- Preventable accidents per 100,000 road miles
- Operating recovery ratio – bus vs. fixed guideway (Metrorail and Metromover)

- Fiscal year revenues by source
- Employee absence rate
- Overtime per person per week

For the Annual Report, vehicle revenue miles are also included.

In the Monthly Report, the following measures are presented, by route:

- Number of riders
- Operating recovery ratio
- Net cost per boarding passenger
- Boardings per revenue hour
- Revenue per total miles

Data Collection Procedure

MDTA doesn't use much data yet from their bus AVL system, as they are still having some operational problems with the system. The data have shown a high percentage of early trips.

Every three years, a research firm conducts a "tracking" survey of 2,000 residents in Miami-Dade County 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 (bus riders, rail riders, potential riders, absolute non-riders)
- Profile of bus/rail/dual transit riders
- Profile of potential riders and non-riders
- Overall attitudes on service (safety, types of required improvements)

In 1998, the South Florida Regional Travel Characteristics Study was conducted, which included a comprehensive on-board transit survey in Miami-Dade, Broward, and Palm Beach Counties to assess ridership characteristics. The primary intent of this survey was to obtain data to calibrate the three-county travel forecasting model. MDTA last conducted its own on-board rider survey back in 1994 and has conducted such a survey every five to ten years on average.

Monitoring and Reporting

See "Measures Used and Standards/Targets" above.

Successes and Challenges with the Performance Measurement Program

In the opinion of the person interviewed, the Service Planning Guidelines do not reflect system objectives, as "political" considerations come into play too often in service implementation decisions. A consultant prepared a performance guideline ranking system to identify a score for each route, and to rank each route. This system has not been implemented, as MDTA staff felt it was too much work.

Nashville, TN: Nashville Metro Transit Authority

Contact Person: Dr. Robert Babbitt, General Manager
Size of Agency: Medium
Transit Modes: Bus, ADA paratransit
Years Performance Measurement Program was Initiated/Most Recently Updated: Nashville MTA has been operating a performance measurement program since 1985 and the program was last updated in 2001.

System Profile

NMTA's mission is "to provide safe, reliable, efficient, customer-friendly public transit and alternatives to driving alone." The agency operates a fleet of 140 buses and 36 demand-responsive vehicles. In 2000, almost 7 million unlinked bus trips and almost 98,000 unlinked paratransit trips were provided.

Goals and Objectives of the Performance Measurement Program

As part of the Short Term Transit Improvement Plan completed for the Nashville MTA, service standards were established to evaluate performance and serve as benchmarks by which to compare the performance of the transit system in the future. Nashville MTA hopes that the performance measurement program and the new service standards will assist the transit system in providing improved service in the future.

Measures Used and Standards/Targets

Four major categories of data are collected. These are miles, hours, riders, and revenue. Derivative measurements such as cost/route, revenue/hour, etc. are generated based on this data. The following are some examples of the derivative measures that are also used:

- *Route spacing* – a matrix of population density and automobiles per household is used to determine route spacing. For example, if an area has over 5,000 persons per square mile and 0.81-1.5 autos per household, the route spacing would be approximately 3/8 of a mile.
- *Route directness* – a ratio of actual route path distance to straight line mileage between terminals. The standard is no more than 1.75.
- *Speed* – local service: 12 miles per hour; express: 22 miles per hour; shuttle: 8 miles per hour
- *Bus stop spacing* – 7 to 8 stops per mile urban; 5 to 6 stops per mile inner suburban; 3 to 4 per mile in suburban
- *Schedule adherence standard* – 90 to 95% during peak service periods and 95% during off-peak periods.
- *Missed trips standard* – No less than 99.5%
- *Farebox recovery standard* – 35%
- *Productivity standard* – 20 passengers per vehicle hour, systemwide

Data Collection Procedure

Measurements are both system-wide and by route type. Route types analyzed are fixed-route, trolley, and magnet (school). Measurements are made monthly. In addition to this regular data collection, a ridership survey is conducted on one route. This survey includes information such as on-time performance, safety, and cleanliness. The staff and GFI registering fareboxes collect this data. Once a month, the MTA conducts a ridership survey to look at on-time performance, safety, and cleanliness. It felt that these "softer" measures were more difficult to approach from a consistency standpoint and did not yield as useful operational data.

Monitoring and Reporting

Once the data have been collected, it is analyzed to see if it meets the performance standards set by the board. Board policy is that if a route is performing at 60% of system average, then there is a requirement for review and recommendation for change. Service adjustments are then implemented twice per year. The only reporting requirement the agency has is to report to the board, and these reports are not tied to funding. NMTA felt that its performance measurement system kept its routes and analysis current and consistent and was useful overall.

In general, the agency found its system to be useful, but it reported issues around the integration of data between farebox and revenue systems. It found that, where there is human interaction, there needs to be some sort of quality assurance controls. It felt that technological innovation could help to minimize errors and thought that GPS and AVL would be an effective tool in the collection of data.

Successes and Challenges with the Performance Measurement Program

Nashville MTA is hopeful that new technologies such as new fareboxes and tracking software would provide the system with a better understanding of its route-level performance. Data integration is considered to be a critical link in performance measurement. The agency hopes to be able to access information on the performance of individual route segments, in addition to entire transit routes as well. The interviewee emphasized that even with improved technology, the human factor is always a variable that must be considered in evaluating the system's performance.

Transferability of Performance Measurement Program to Other Transit Systems

Nashville MTA's performance measurement program and service standards are certainly transferable to other systems, although the values themselves would have to be reevaluated to match the local conditions. MTA's program is quite comprehensive and would serve most mid-sized transit systems well.

New South Wales, Australia: State Transit

Size of Agency: Large
Transit Modes: Bus and Ferry
Years Performance Measurement Program was Initiated/Most Recently Updated: The program has been in place since 1997. Annual reports have been produced for the last 6 years. The program has been continuously improved since inception. It is currently being reviewed as part of the process for Quality Systems accreditation (ISO 9000/2). State Transit (ST) should be fully accredited by end of 2002.

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 annum) 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 on over 1,000 kilometers on 360 routes with an average of 20 minutes per passenger trip (for an average distance of 5.7 kilometers).

Goals and Objectives of the Performance Measurement Program

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

The performance measurement program is designed to monitor the way in which State Transit is meeting its goals and objectives under legislation that set the operator as a trading enterprise. This legislation required that an overall business management system is put in place, which 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 towards regional development and decentralization.

In order 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 at affordable levels.

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 likewise taken having regard for the way in which the objectives may be affected. For example, the bus maintenance performance target is that no preventable (through regular maintenance) mechanical failures will occur. 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 Used and Standards/Targets

As a result of the main corporate goal, the main performance measure driving the organization is the level of patronage in general and the transit mode share in particular. These objectives 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.; p.m. peaks; off-peaks; 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 are being met. This will be discussed in more detail in Table 4 below.

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.

Table 4. State Transit Performance Objectives

Objective	Performance Measures (Targets)
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	Percentage of population within 400 meters of a bus stop between 6 a.m. and 6.30 p.m. Monday to Saturday and 800 meters at other times (target 95%) All routes to provide connections to regional centers Frequent community consultation activities Regular attitudinal surveys conducted Regular monitoring of customers complaints Bus fleet: 25% low floor; 20% wheelchair accessible; 35% air-conditioned
Reliability	On-time running in normal traffic conditions (target 95%) Definition: no later than 5 minutes. Example achievement: 96% through 2001 for buses and just over 99% for ferries (on-time running is measured at terminus and at mid-points along the route (buses) No early running Mechanical failures preventable through regular maintenance Number of changeovers (buses that require in service replacement) per 100,000 kilometers (target is 98% mechanical reliability for buses)
Safety and Security of Passengers	All buses fitted with CCTV units All buses in radio contact with control center Non-slip floors on all buses
Comfort	Fleet average age (12 years is the contractual obligation with Government Agency) Number of buses: air-conditioned; accessible to people with disabilities; quality seating; ease of boarding Buses cleaned internally daily; washed every 3 days; buy environmentally friendly buses only in future
Staff Training to Provide "Friendly" Service	Standards set for customer service training Help for those who do not understand the system Ongoing communication of decisions
Travel Information to Passengers	Review all public timetables periodically Numbers of transit shops (5 in 2002); used for marketing, ticket sales, and traveler information points Numbers of agents selling tickets and providing information
Efficiency to Keep Costs Down and Fares at Affordable Levels	Average operating cost/passenger trip for buses Average operating cost/passenger trip for ferries Cost/vehicle-kilometer for each main cost center

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 percent compared with other operators (this system 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 lead 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.

Monitoring and Reporting

The EIS is used to obtain management reports directed at 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:

- 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 results include the following features of bus service and ratings:

- 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 with the Performance Measurement Program

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

Lessons/Challenges

- To be successful, the program must have a strong internal champion.
- The program needs adequate resources to be properly maintained.
- Must have dedicated training program for new staff
- Staff need to be encourage 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).
- With the upgrade, there will be added functions, including the ability to customize reports to suit specific needs.

Transferability of Performance Measurement Program to Other Transit Systems

EIS could be transferred to other operators that have HASTUS-based systems.

New York, NY: Metropolitan Transportation Authority-New York City Transit

Size of Agency: Large
Transit Modes: Bus, heavy rail, paratransit

System Profile

The Metropolitan Transportation Authority-New York City Transit (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 Used and Standards/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 decades.
- *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 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 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 budget and actual financial results on a year-to-date basis, weekday and weekend subway and bus ridership on a monthly and year-to-date vs. the previous year basis, and several financial tables.
- *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.

Successes and Challenges with the Performance Measurement Program

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

A number of documents were received from MTA-NYCT, which were summarized in previous working papers. These documents include:

- *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)*

Two other documents received are briefly summarized below.

MTA's 2001-2005 Strategic Business Plan (December 2000)

The three goals listed in this document pertain to the MTA and its agencies. They are:

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

There are interagency 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.

In terms of the specific strategies, some community concerns are addressed, especially in the interagency portion of the document. Under the goal of improving customer satisfaction, the first strategy is to expand regional accessibility. Under the goal of improving safety for employees and customers, the second strategy is to respond to environmental concerns. However, specific performance indicators are not listed here, most likely because they are considered the purview of each individual agency.

For NYCT, under the goal "Improve Safety for Employees and Customers," two indicators are listed:

- Lost-time and restricted duty cases per 200,000 work hours
- Injuries per million customers by mode (subway and bus)

The key question is, "Do injuries per million customers reflect safety?" Some safety experts disagree and advocate an indicator that looks at rates of unsafe behavior. If bus drivers routinely engage in unsafe behavior, safety is compromised even if the number of accidents or injuries is low. The thinking is that, under these conditions, an accident is waiting to happen. For NYCT, train crew behavior is emphasized in one of the tactics under the first strategy.
Under the goal "Improve Customer Satisfaction," the indicators listed include:

- Service regularity (this has been replaced by wait assessment)
- En route schedule adherence
- Mean distance between failures (subway)
- Mean distance between service interruptions (bus)
- Overall customer rating (subway)
- Overall customer rating (bus)

Under the goal "Improve Cost-effectiveness," three indicators are listed:

- Cash deficit before subsidy
- Cost per passenger mile
- Subsidy per passenger mile

2001 Departmental Goals
This document lists performance indicators and goals for the following NYCT departments:

- Department of Subways
- Department of Buses
- Department of MetroCard Operations
- Department of the Executive Vice President
- Department of Telecommunications and Information Services
- Department of Capital Program Management
- Department of Law
- Office of Labor Relations
- Office of System Safety

A set of strategies and related performance indicators are presented for each department, along with results for the previous year (2000 Goal and 2000 Actual) and current year goals.

For the Department of Subways, under the strategy "Improve Safety for Customers and Employees," the indicators listed are subway customer injuries per million customers and subway fires. For the former indicator, the 2000 Goal is 2.68; 2000 Actual is 3.24, and the 2001 Goal is listed as 3.08.

In the program goals section, for the same strategy, 2000 Annual Goal, 2000 Accomplishment, and 2001 Annual Goal are listed for numerous work activities. An example of a work activity is "remove debris with two vacuum trains." The goals are:

- 2000 Annual Goal: Remove debris along 300 miles of track with the vacuum train.
- 2000 Accomplishment: Removed debris along 312 miles of track with one vacuum train.
- 2001 Annual Goal: Remove debris along 600 miles of track with two vacuum trains.

Oshkosh, WI: Oshkosh Transit System

Contact Person: Mark Huddleston, Director of Transportation
Size of Agency: Small
Transit Modes: Bus, ADA paratransit, rural paratransit, demand-responsive service

System Profile

Oshkosh provides 3,137 daily bus rides and 450 daily rides on eight different demand-responsive services including ADA Complementary Paratransit. With a fleet of 42 buses, Oshkosh Transit provides service within the City of Oshkosh, intercity service to Neenah (connecting with Valley Transit), and rural service throughout Winnebago County.

Oshkosh Transit began providing service on January 1, 1978. Oshkosh Transit is a part of the Transportation Department of the City of Oshkosh. Mark Huddleston has served as Director of Transportation since the inception of Oshkosh Transit.

Goals and Objectives of the Performance Measurement Program

Performance measurements have been most effective in Oshkosh in determining the performance of fixed-route service. Routes are modified or eliminated if they are not performing effectively. As a result, Oshkosh Transit has been able to most effectively use its resources to serve the maximum number of customers.

Wisconsin has considered basing funding levels based on performance, but has yet to implement that program. Oshkosh Transit has compared favorably with respect to its peers within the state as they relate to ridership, productivity, cost per passenger, and passengers per capita.

Measures Used and Standards/Targets

Ridership standards are as follows, based on historic levels and adjusted for inflation where appropriate:

- Annual ridership — 1.08 million rides
- Passengers per mile — 1.9 passenger per mile
- Passengers per revenue hour — 27 passengers per revenue hour
- On-time performance — 95 percent of all trips
- Cost per passenger — $3.49 per passenger
- Fare recovery ratio — 16 percent of total cost
- Cost per vehicle hour — $83.07 per vehicle hour (fixed-route)
- Cost per vehicle mile — $6.39 per vehicle mile
- Percentage of accessible vehicles — 100 percent
- Passengers per capita — 16 passengers per capita

Monitoring and Reporting
Performance measures are reported to four groups:

- The Wisconsin Department of Transportation (WISDOT), which provides the largest percentage of operating revenue within Oshkosh's budget
- The Oshkosh City Council (because Oshkosh Transit is part of a municipal department for the City of Oshkosh) – the governing body of the transit agency
- Citizen groups
- Internal staff within Oshkosh Transit and the City of Oshkosh

Performance measures reported to the City Council and WISDOT include:

- 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
- Revenue passengers per capita

Successes and Challenges with the Performance Measurement Program
The elimination of non-productive services has been aided by performance measures and has allowed the agency to provide a substantial level of service for a city of its size while controlling costs**.**

Transferability of Performance Measurement Program to Other Transit Systems
The State of Wisconsin requires standardized reporting requirements so the measures are replicated in other urban transit agencies within Wisconsin.

Portland, OR: Tri-Met
Contact Person: James Hergert, Manager of Service Planning
Size of Agency: Medium
Transit Modes: Bus, light rail, ADA paratransit, etc.
Years Performance Measurement Program was Initiated/Most Recently Updated: Performance measurement program has been in place for at least 15 years

System Profile
Tri-Met was founded in 1969 to provide transit service in the three counties of the Portland metropolitan area. Tri-Met maintains a fleet of approximately 670 buses, 70 light rail vehicles, and 170 demand-responsive Tri-Met LIFT vehicles. In 2000, Tri-Met provided almost 62 million unlinked bus trips, 24 million unlinked light rail trips, and 736,000 unlinked paratransit trips.

Goals and Objectives of the Performance Measurement Program
Tri-Met originally adopted the performance measurement program due to an internal management decision. It was considered to be good business practice and in tune with the philosophy of the system's board of directors at the time. Tri-Met's performance measurement program is not legislatively mandated nor is it tied to any funding sources. Tri-Met believes that

the performance measurement program has served the agency well and sees the program continuing in a similar fashion for years to come.

Measures Used and Standards/Targets

Tri-Met has both system-wide performance measures and route-specific measures. Following is a list of Tri-Met's primary performance measures and indicators:

- *Fare recovery ratio* — fares should cover an average of 30% of system cost
- *Missed Trips* — 99.8% of all scheduled trips should operate in their entirety each day
- *Bus Route Spacing* — routes should be 1/2-mile apart in urban areas and no more than 1 mile apart in suburban areas
- *Schedule Efficiency* — system average schedule efficiency should be a minimum of 75% for each weekday
- *Transfers* — travel between downtown Portland and all residential areas and major activity centers served by Tri-Met should be possible with no more than one transfer
- *Bus Stop Spacing* — dictated primarily by land use — Tri-Met has 4 tiers of bus stop spacing as follows:
  - Group 1: 400-600 ft — business districts, shopping centers, transfer points, hospitals, and high density housing
  - Group 2: 500-750 ft — contiguous, fully developed residential areas and medium to low density commercial areas
  - Group 3: 600-1000 ft — low density residential development
  - Group 4: as needed, but generally not closer than 750 ft — rural or isolated areas

Data Collection Procedure

Tri-Met's research division attempts to measure community satisfaction and customer perception of the transit system's rail extensions, bus service, etc. Telephone surveys of the general public are conducted approximately twice a year. Many of the same questions are repeated to get a sense of how public opinion changes over time. Tri-Met considers these surveys to be very effective at providing the system with valuable feedback which plays a part in shaping the direction of the transit system.

Monitoring and Reporting

Tri-Met's data management, monitoring, and reporting procedures are quite rigorous and are certainly among the stronger elements of the performance measurement program. Performance standards are reported quarterly, but data is collected on an ongoing basis by Tri-Met. Tri-Met believes that their performance measurement program is useful and that the data provide the transit system with a basis for prioritizing transit improvements. Tri-Met typically makes service changes to increase ridership potential or to address on-time performance or passenger loading problems. Tri-Met has a fairly clearly defined chain of events established for when a particular performance measure fails or exceeds its standard. Among the possible actions include additional service, service modifications, and elimination of poorly performing service.

Successes and Challenges with the Performance Measurement Program

Tri-Met's performance measurement program has been a valuable asset to the transit system and has become an integral element affecting the decision making process. The transit system feels as though the existing measures do a good job of evaluating system wide performance and are still relevant even though the measures have not been updated in 15 years. The original performance measurement program was established based upon data collected throughout the industry. Tri-Met believes that their performance standards effectively reflect the system's objectives and serve as a good measurement tool.

The volume of data has increased considerably in recent years due to technological improvements such as AVL and automatic passenger counters. The real challenge faced by Tri-Met is figuring out what to do with all the data they collect now. At present, the data are summarized on a quarterly basis. Tri-Met may be able to improve their data processing capabilities by creating aggregate performance measures to summarize the large amount of data collected.

Transferability of Performance Measurement Program to Other Transit Systems
Tri-Met believes that most of their performance measures are transferable to other parts of the country, although they indicated that a lot of would depend on whether systems can collect the requisite information to support the performance standards.

San Antonio, TX: VIA Transit
Contact Person: Diana Montemayor, Manager of Budget and Special Projects
Size of Agency: Large Urban
Transit Modes: Bus, streetcars, ADA paratransit

System Profile
VIA is funded by a permanent half-cent sales tax that is collected within its service area. VIA currently operates 106 bus routes that are divided into radial, limited stop, express, crosstown, circulator, and streetcar lines. Ridership on VIA totals more than 44 million passengers on VIA's buses and nearly one million unlinked trips on VIAtrans. VIA utilizes nearly 500 buses and more than 200 demand-responsive vehicles. Average weekday ridership on VIA's bus system exceeds 136,000.

VIA is governed by an eleven person Board of Trustees. Ten members are appointed: five by the City of San Antonio, three by Bexar County, and two by the Suburban Council of Mayors. Those ten members in term elect a Board Chair who is the Board's eleventh member. John Milam is President/CEO of VIA.

Measures Used and Standards/Targets
Performance standards include:

- Paratransit utilization – 2.02 passengers per service hour
- On-time performance, fixed-route – 95 percent at end of line, 90 percent at transfer points, and 85 percent at all other points
- On-time performance, paratransit – 92 percent within 20-minute window
- Vehicle accidents per million miles – 20 or less
- Pay-to-platform hours – 1.07 weekday fixed-route, 1.05 daily service, and 1.03 paratransit
- Passenger complaints, paratransit – one per 350 passenger trips
- Trip reservations, paratransit – 90 percent of phone calls answered within two minutes

Additional measures are monitored monthly and compared to standards set by VIA's President:

- Ridership
- On-time performance
- Accident rate
- Road call rate
- Pay-to-platform hours
- Passenger complaints

Staff also internally tracks the percentage of accessible vehicles.

Monitoring and Reporting
Performance measures reported to the Board of Trustees consist of:

Annually
- Annual Ridership

Monthly
- Passengers Per Hour
- On Time Performance
- Vehicle Accidents per 100,000 Miles
- Road Calls Per 100,000 Miles
- Cost Per Passenger
- Farebox Recovery Ratio
- Cost Per Vehicle Hour
- Cost Per Vehicle Mile
- Pay to Platform Hours
- Passenger Complaints per 10,000 hours
- Bus Changes per 100,000 miles
- Bus Inspections per 100,000 miles
- Paratransit Inspections per 100,000 miles

Line service ridership is measured for each route in each of the following route types: Major Radial, Minor Radial, Major Limited Stops, Major Express, Minor Express, Crosstown, and Streetcar. Routes are closely evaluated if they reach "critical status," in which case Board approval each quarter is required for continuation of the route. The purpose of the route performance standards is to ensure that routes are serving an acceptable number of passengers to warrant continuation. Regular monitoring of the system is used to identify positive and negative trends and to take corrective action as needed. Performance standards also assist in budget adherence.

Successes and Challenges with the Performance Measurement Program
Given an environment of limited resources, VIA is able to continue to provide a high level of service throughout Bexar County. Rated most efficient transit service in Texas (and 11th overall) in North Carolina survey of transit agencies.

Transferability of Performance Measurement Program to Other Transit Systems
Performance measures are transferable to other agencies.

San Diego, CA: San Diego Association of Governments

Size of Agency: Large
Transit Modes: Bus, ADA paratransit, trolley
Years Performance Measurement Program was Initiated/Most Recently Updated: The standards are adjusted every year.

Agency Profile

The San Diego Association of Governments (SANDAG) is a regional planning agency governed by a board composed of representatives of 19 local governments as well as several advisors. SANDAG was formed in 1966 as the Comprehensive Planning Organization but 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.

Goals and Objectives of the Performance Measurement Program

SANDAG works closely with the 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 are being used to assess the impact and priority of new transit capital projects in the new 20-30 year regional transportation plan.

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 Used and Standards/Targets

The impact and priority of new transit capital projects in the new 20-30 year regional transportation plan is assessed using measures in the following areas:

- *Mobility*—average travel time per trip
- *Accessibility*—Percent of total employment/regional centers within "x" minutes of a location via transit (30 vs. 45 minutes being assessed for "x")
- *Reliability*—roadway segment volume-to-capacity ratio. The higher the ratio, the more likely travel times and transit on-time performance will be variable.
- *Equity*—average system user cost per trip/average user cost per trip for low income/minorities/elderly
- *Livability*—acres of vacant land developed (reflective in regional land use plan)
- *Sustainability*—tons of smog-forming pollutants (systemwide)
- *Efficiency*—total capital and operating cost/travel time saved per person; total user travel cost/trip

These measures are applied at both a regional and project level of analysis, with projects compared to baseline conditions using the same measures. Additional project-level performance measures include travel time saved per cost and number of trips served. Qualitative criteria also applied in project-level evaluation include smart growth, critical linkages, and social equity.

San Diego, CA: Metropolitan Transportation Development Board

Contact Person: Conan Cheung, Associate Transportation Planner, Planning & Development

Size of Agency: Large
Transit Modes: Bus, ADA paratransit, trolley
Years Performance Measurement Program was Initiated/Most Recently Updated: The standards are adjusted every year.

System Profile

MTDB was formed in 1975 and is governed by a 15-member board. MTDB coordinates the Metropolitan Transit System (MTS), which provides express bus, light rail, local/urban bus, and demand-responsive services through Chula Vista Transit, National City Transit, San Diego County Transit, San Diego Transit, San Diego Trolley, and eight demand-response operators. Together, these agencies maintain approximately 525 buses, 125 light rail vehicles, and 130 demand-responsive vehicles. In 2000, these agencies provided approximately 84 million bus rides, 29 million light rail rides, and 865,000 paratransit rides.

Goals and Objectives of the Performance Measurement Program

MDTB uses a three-tiered performance measure program, consisting of:

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

The performance standards are consistent with the goals and objectives in the MTDB Short-Range Transit Plan.

Measures Used and Standards/Targets

The following performance indicators are used for the different reports.

Quarterly Operations Report

- Passengers per mile
- Passengers per hour
- Subsidy per passenger
- Cost per hour

Quarterly Budget Report

- Budgeted vs. actual costs (monthly and quarterly, aggregated to an annual comparison). There is an issue of not receiving data on time from operators.

Annual Route Monitoring Report

- Passengers per mile
- Passengers per hour
- Passenger miles per seat mile
- 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
- 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.

MTDB uses a set of performance standards, as follows:

- Passengers per mile – operators set own targets, approved by MTDB
- Passengers per hour – operators set own targets, approved by MTDB
- Cost per passenger – increases should not exceed increases in the Consumer Price Index
- % trips completed – 99.8 percent
- On-time performance – 90 percent (operators need to show increase each year to meet target)
- Farebox recovery ratio – increase every year
- Passengers per population – increase at rate higher than population increase

Data Collection Procedure

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
- 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, which allows operators to submit the form electronically. Passenger data are also requested by passenger type, when available.

Service providers under the MTDB umbrella conduct periodic customer surveys. SANDAG conducts an on-board customer survey for all trips on all routes over a three-year period. SANDAG also collects on and off ridership for all trips on all routes once per year. MTDB has found that customer perception of service can be impacted by recent positive or negative occurrences.

Monitoring and Reporting
As their names suggest, the two quarterly reports contain statistics measured quarterly, while the Route Monitoring Report reports measures on an annual basis.

All of the data collected have been found to be useful. The Quarterly Operations Report addresses reasons why changes exist from quarter to quarter, which are documented in the report. 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 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
- Farebox recovery ratio

Successes and Challenges with the Performance Measurement Program
MTDB is currently revamping the existing performance measure system to combine the three tiers into a single reporting system and integrate it with the TDA reporting requirement

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

Transferability of Performance Measurement Program to Other Transit Systems
MTDB feels they have a rigorous performance monitoring system, and that such a program would be transferable to other parts of the country.

Summary of Performance Measures Used by Interviewed Agencies
Table 5 lists the most commonly used performance measures among the agencies interviewed. At least 25 percent of the surveyed agencies monitor some variation of these measures. Note that no measures of availability, community, travel time, or capacity were used by 25 percent or more of the surveyed agencies. There was no apparent correlation between agency size and the type or number of performance measures used, but the metropolitan planning organizations included in the survey tended to use community-oriented measures that the transit agencies did not.

Table 5. Commonly Used Performance Measures Among Surveyed Agencies

Action Measured	Common Measures	Description
Used by 25% to 50% of Surveyed Agencies		
Road Calls	Mean distance between failures; road miles between reported defects; road calls per *X* miles	The number of unplanned revenue service road calls per specified distance or time; a maintenance measure
Employee Productivity	Overtime hours worked per person per week; employee absence rate; pay-to-platform hours	An economic measure of employee work output
Missed Trips	Percent missed trips; percent trips completed	Trips removed from the daily schedule; a service monitoring measure
Complaint/ Compliment Rate	Passenger complaints/compliments per boarding, per trip, or per hour	The number of passenger complaints or compliments per a specified number of hours, trips, or passengers; a service monitoring measure
Passenger Load	Load factor; customers per bus	The number of people on board a transit vehicle; a service monitoring measure
Used by More than 50% of Surveyed Agencies		
Cost Effectiveness	Farebox recovery ratio; cost per passenger mile; subsidy per passenger	The ability to meet the demand for transit services given existing resources; an economic measure
Ridership	Passengers per hour; boardings per hour; boardings per mile	The number of passengers transported; an economic measure
On-time Performance	On-time performance; schedule adherence	The percentage of transit vehicles departing or arriving at a location on time; a service monitoring measure
Cost Efficiency	Cost per vehicle hour; operating expense per vehicle mile	The ability to provide service outputs within the constraints of service inputs; an economic measure
Accident Rate	Vehicle miles between accidents; accidents per *X* miles; injuries per *X* boardings	The number of accidents per specified distance or time; a safety and security measure

SUMMARY OF DEMAND-RESPONSE AGENCY INTERVIEWS

Examining the approach of three demand-responsive services to performance measures indicates varying approaches. Measuring performance in demand-responsive service is somewhat different than 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 service requires a significantly different service delivery approach since individuals trips must be scheduled and driver 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 reduction of levels in other service modes

Cost control is an important issue but each case study also focuses in different ways on means to achieve service quality towards the customer and with respect to the community.

The case studies are:

- Handivan – The ADA Complementary Paratransit Service for TheBus in Honolulu, Hawaii. Transporting over 700,000 passengers per year ranks Handivan among the larger ADA Complementary Paratransit operations in the United States. Maintaining quality service to the community is an ongoing challenge with a demand-responsive service of this size.
- HARTplus – The ADA Complementary Paratransit Service for HARTline in Tampa, Florida has a ridership level of 40,000 passengers to the year that makes it a smaller paratransit operation. However, HARTline operates in a medium size system in the United States and its efforts toward disability transportation are focused upon a multimodal, mobility management approach.
- Community Transit – Operating a general public demand-responsive service for Saint Lucie County, Florida, Community Transit provides approximately 170,000 trips per year. Implementation of fixed-route service for the first time in Saint Lucie County is designed to improve the level of mobility options for all within the community and speaks to the inherent limitations of demand-responsive service for providing a high volume of trips at a reasonable cost.

Honolulu, HI: Handivan

Agency Name: City and County of Honolulu Department of Transportation Services
Location: Honolulu, HI
Size of Agency: Large
Transit Modes: ADA demand-responsive service

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 could 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.

Goals and Objectives of the Performance Measurement Program

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
Report above indicators to City and County of Honolulu on a monthly basis.

Successes with the Performance Measurement Program
- Increased service level productivity,
- Improved on-time performance, and
- Reduced no shows.

Challenges with the Performance Measurement System
- Lack of real-time data since 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).

Transferability of Performance Measurement Program to Other Transit Systems
The program would be transferable to other systems.

ADA Service and Handivan
ADA requirements shape the manner that Handivan provides service. Handivan does not deny any trips and 80 percent of its trips are subscription trips during the peak hours of service. Handivan 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 ensuring that the service is a quality service. 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 allow curb-to-curb service,
- Travel training for fixed-route service, and
- Accessible fixed-route service (TheBus vehicles are 100% accessible)

Demand-Responsive Service
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. The fixed-route emphasis is providing the most service in an efficient manner. Demand-responsive service

focuses on efficiency in scheduling and service delivery that will allow quality service through effective routing and husbanding of resources.

Nevertheless, fixed-route and demand-responsive services share common goals:

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

Tampa, FL: HARTplus

Agency Name: Hillsborough Area Regional Transit (HARTline)
Location: Tampa, Florida
Contact Person: Lauren Skiver, Transit and Customer Service Coordinator
Size of Agency: Medium
Transit Modes: ADA demand-responsive service
Years Performance Measurement Program was Initiated/Most Recently Updated: 1999

System Profile

HARTline has operated HARTplus directly since 2000, providing about 40,000 demand-responsive trips per year. Service is only offered within ¾-mile of local bus routes and only when fixed-route service is operating in a specific area. Fixed-route service increases on the basis of the number of zones traveled; ADA service costs double the fixed-route fare based on the zones traveled. ADA service costs comprise approximately 3 percent of HARTline's operating budget—about one-half to one-quarter of the percentage spent at other transit agencies.

Goals and Objectives of the Performance Measurement Program

Assure that while ADA regulations are followed, service costs are controlled, and mobility options are offered to persons with disabilities

Measures Used and Standards/Targets

Measures reported monthly:

- Ridership,
- Percentage of trips denied,
- Passenger complaints,
- Percentage of ADA Applications approved,
- Percentage of no shows per month,
- Cancellations,
- Number of certified passengers,
- Number of passengers travel trained,
- Passenger trips by purpose,
- Trip purpose,
- On-time report,
- Commendations,
- Daily work trips, and
- Missed trips (60 minutes late).

Measures reported annually:

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

Monitoring and Reporting

On-time performance, complaints, commendation, daily work trips, missed trips, and percentage of trips denied are reported to the Board of Directors. Passengers per capita and average trip time are reported internally. Daily work trips are reported to citizens' groups.

Successes and Challenges with the Performance Measurement Program

Improved on-time performance by adjusting parameters of Trapeze scheduling software

Transferability of Performance Measurement Program to Other Transit Systems

Performance measurement program can be used in other systems.

ADA Paratransit and HARTline

HARTline has developed the following strategy for paratransit service:

- Comply with ADA regulations
- Offer a range of mobility options to persons with disabilities by addressing individual travel needs
- Provide a high level of complementary ADA service

Funding levels for overall transit service are low at HARTline, and providing a high level of ADA paratransit service (10 to 15 percent of the operating budget) would result in significant cuts in an already modest fixed- and flexible-route transit network

HARTline decided to operate ADA paratransit directly in 2000, replacing a private provider whose performance was considered unsatisfactory. HARTline started in many respects with a new ADA paratransit service. Management decided to incorporate and refine many of the best practices that had developed in the transit industry since the ADA went into effect in 1990. Service delivery incorporated the following strategy:

- Strict limitation of eligibility on ADA paratransit to those who met ADA standards
- Working closely with each customer to assist in development of mobility strategies for their particular circumstances
- Providing 100 percent accessible fixed-route buses
- Developing flexible routes in outlying areas to provide curb-to-curb service in a more effective manner
- Conducting travel training to assist persons with disabilities in navigating fixed- and flexible-route service
- Incorporating pricing strategies within the ADA guidelines that encourage fixed-route and flexible-route service (paratransit fares were twice the cost of fixed-route service)
- Providing quality service (less than 1 percent late) for those who ride ADA Complementary Paratransit service

St. Lucie County, FL: Community Transit

Agency Name: Community Transit
Location: Saint Lucie County, Florida
Size of Agency: Small
Transit Modes: General demand-responsive service

System Profile

Saint Lucie County, Florida, is located on the "Treasure Coast" of southeast Florida. According to the 2000 U.S. Census, the county population in 2000 was 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 in Saint Lucie County.

The Council on Aging of Saint Lucie County operates Community Transit per a three-year transportation service agreement issued by Saint Lucie County for the period of July 1, 1999, to June 30, 2002.

Community Transit provides demand-responsive service. 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 provides demand-responsive service to the general population on a countywide basis. 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 (13 percent) of Community Transit's demand is for work trips.

Operating costs for the demand-responsive service have increased by 87 percent between 1996 and 2000. Community Transit annual operating costs were $864,220 in 1996 and increased to $1,612,745 in 2000. Overall operating data for Community Transit are listed in Table 6.

Goals and Objectives of the Performance Measurement Program

Measure ability of Community Transit to meet budgeted goals in terms of cost, hours, productivity, and ridership

Measures Used and Standards/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.

Data Collection Procedure

Data are gathered and compiled into monthly reports.

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 St. Lucie County (which uses it for their Transit Development Plan).

Successes and Challenges with the Performance Measurement Program

Community Transit has successfully maintained the cost per trip for demand-responsive service under $10 per trip for five years.

Computer software is not adequate to measure actual data and scheduled data since trips are currently scheduled manually.

Transferability of Performance Measurement Program to Other Transit Systems

Measures are transferable.

ADA Service and Community Transit

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 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.

Table 6. Community Transit Operating Summary, FY 1996-2000

Characteristic	FY 95/96	FY 96/97	FY 97/98	FY 98/99	FY 99/00
Number of Vehicles	26	26	31	37	38
Passenger Trips	86,783	128,769	125,243	149,564	158,469
Vehicle Miles	369,885	369,985	491,840	573,750	614,815
Revenue Miles	301,200	344,086	449,840	508,537	537,823
Vehicle Hours	25,480	22,554	25,900	30,938	N/A
Revenue Hours	13,488	18,401	20,250	24,085	33,466
Passengers Per Vehicle Mile	0.23	0.34	0.25	0.26	0.25
Passengers Per Revenue Mile	0.29	0.37	0.28	0.29	0.29
Passengers Per Vehicle Hours	3.40	5.70	4.83	4.83	N/A
Passengers Per Revenue Hours	6.43	6.99	6.18	6.20	4.73
Total Operating Costs	**$864,220**	**$1,158,731**	**$1,193,774**	**$1,462,146**	**$1,612,745**
Cost Per Trip	$9.95	$8.99	$ 9.53	$9.77	$10.17
Cost Per Vehicle Mile	$2.33	$3.13	$2.42	$2.54	$2.62
Cost Per Revenue Mile	$2.86	$3.36	$2.65	$2.87	$2.99
Cost Per Vehicle Hour	$33.91	$51.37	$46.09	$47.26	N/A
Cost Per Revenue Hour	$64.07	$62.97	$58.95	$60.70	$48.19

Source: Community Transit Operating Data

Demand-Responsive Service

Community Transit is currently transitioning from an exclusive demand-responsive service to an agency that provides demand-responsive and fixed-route service. 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. Performance measurement of ridership and costs will be critical indicators. Among key differences between demand-responsive and fixed-route service cited by Community Transit are the following.

On-Time Performance: Demand-responsive trips have a one-hour window with respect to arrival time. A vehicle scheduled for a 10 AM pickup may arrive between 9:30 AM and 10:30 AM. 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.

CUSTOMER SATISFACTION SURVEY CASE STUDY

Agency Name: Capital Area Transportation Authority
Location: Lansing, MI
Size of Agency: Medium
Transit Modes: Urban fixed-route bus, ADA demand-responsive service

Introduction and Background

The Capital Area Transportation Authority (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 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 with CATA;
- 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 the bus arrives at the origin stop on time,
- Improvements to frequency of service,
- Ensuring that passengers are free from nuisance behavior while waiting at the CATA Transportation Center (CTC), and at bus stops,
- Adding shelters at bus stops,
- Improving lighting at the bus stops,
- Availability of seats on the bus, and
- Bus drops riders off 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 and findings of 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: A Handbook for Measuring Customer Satisfaction and Service Quality.

The major differences or additions to the method are (1) sections in the survey on Customer Loyalty and Price Sensitivity and (2) in the analysis of the responses, a Quadrant Analysis. 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 questionnaire for the telephone interview consists of 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 get 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;
- The bus is operated in a manner that provides a smooth ride;
- 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., 1-7) scale. The impact score approach involves the following steps.

First, the attributes which have the most impact on overall satisfaction must be determined. This is done by calculating % 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 *t*-test is conducted to determine statistical 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 7. 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 w/o 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 7. CATA Rider Primary Drivers of Satisfaction

	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. The 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:

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

The overall loyalty results for the 2000 survey are presented in Figure 1. The percentage of secure riders within each route group is presented in Table 8.

Figure 1. Loyalty Towards CATA

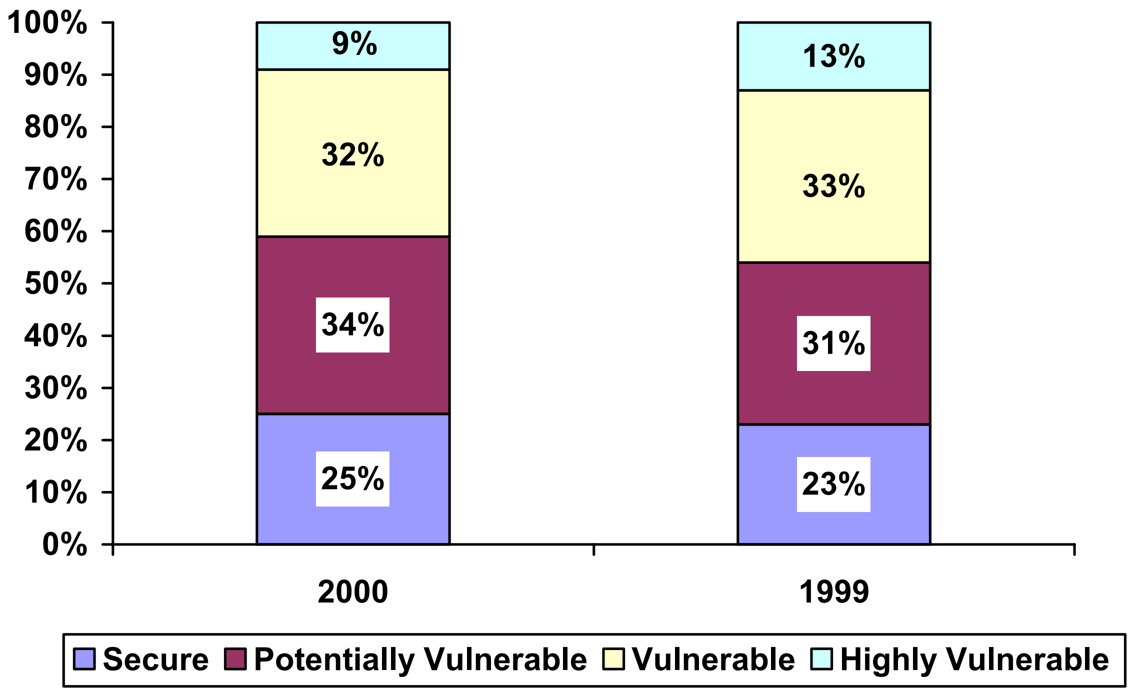

Table 8. Rider Loyalty by CATA Route Group

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, 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". 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".

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. 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.

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

The specific service quality attributes identified for each category are presented in Table 9.

Table 9. Quadrant Analysis of CATA Service Quality Attributes

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

PERFORMANCE MEASUREMENT IN SERVICE INDUSTRIES

This section contains a summary of performance measures used by private industries and discusses how they might be applied to the transit industry. Five case studies of relevant service industries are also included. These industries are:

- Temporary help agency
- National pizza chain
- Furniture manufacturer
- National insurance company
- National retailer

Summary of Private Industry Performance Measurement and Comparative Application to the Transit Industry

When discussing performance measures with private industry representatives, they most often structure measures into three categories: revenue and cost measures, system and change monitoring, and customer satisfaction and loyalty measures. Examples of these three types of performance measure, taken from both private and transit industries, are cited below.

Category	Examples
• Revenue and cost measures	gross profit margin, net income, percent of revenue from fare box, costs 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 and loyalty	primary customer satisfaction measures overall, and on service attributes; whether service meets customers' expectations; whether customers will recommend service, 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/loyalty measurement was really only a subcategory of system monitoring—one among many indicators to track.

Then came change, first in the automotive industry. For example, Chrysler built the K cars that met internal system performance measures—except customers didn't like them. The countering "pull-factor" on customers was the introduction of products, by brands such as Toyota and Honda, which had much improved quality at a comparable price point. This improved quality included factors such as longevity, which generated higher re-sale values. This completely changed the overall value equation by increasing customer expectations for all brands, literally forcing competitors, mostly domestic, to adopt new initiatives to improve these same factors or risk losing the very customers that they considered their core. General Motors, for instance, had a market share approaching 60% in the U.S. 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 brand—in many cases, excluding consideration of other products unless their current product disappointed them—in the new paradigm, loyalty to brands weakened. Manufacturers in other domestic industries took note. Today, consumers require manufacturers to not only provide comparable levels of quality and product satisfaction but 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 have searched for ways to measure not just the traditional things-gone-wrong (TGW) or satisfaction levels, but for ways to add extra visible levels of service or features, and then track these elements to determine if they are truly differentiating themselves from their competitors.

Among service industries, a corresponding trend had an added effect. Starting in the 1990s, customer complaints increased dramatically. The reasons for this are various. Either the level of service declined (perhaps with an overload of customers), or customer expectations for service rose, or customers became more vocal about their complaints. In the health care industry, as in air service later on, the government took note and 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. The results are posted on a website.

With the private sector emphasis on listening to "the voice of the customer," customer satisfaction and loyalty measurement came into its own as a performance measure category among private industries, largely replacing internally generated system and change monitoring measures in importance. Customers now evaluate system components, which has largely replaced reliance on secondary data to judge the condition of the system.

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 as "it takes five times the costs to attract a new customer as to retain an existing customer."

Among transit industries, while customer satisfaction measurement 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," one alongside a host of other system (secondary) measures. For some transit systems, the concept is that trips are serviced and counted, rather than customers. Moreover, as recorded in the literature review, there have been few attempts as yet to link revenue/profitability measures with customer satisfaction measures. (A notable exception is the recent research effort at CTA to link increases in the customer loyalty index with increases in "choice" riders.)

The reasons why customer satisfaction/loyalty measurement has not taken hold as quickly in the transit industry as in the private sector are extensive. Transit agencies often have differences in goals and objectives, and barriers that affect the extent to which they can regard customer satisfaction and loyalty measurement as a full-fledged performance measure category, on a par with its status among private industries. These 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;
- Lack of financial resources, as customer satisfaction and loyalty measurement often requires outside consultants and updated technology for maintaining customer databases and transmitting reports electronically to make their impact timely; and
- 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 on-going 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. Finally, 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. Most successful have been efforts to 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.

While both private sector service companies and transit agencies track revenue-based performance measures, performance measures among Fortune 500 private industry companies are more likely to be driven by measures related to customer satisfaction and customer loyalty. Private service industries are driven by the goal to maintain and increase repeat customer business.

Performance measures reported by transit agencies are more likely to be driven by goals oriented to monitoring the system and goals that change over time. The latter includes measures of service and cost efficiency, such as the number of boardings per hour or per mile, the number of unlinked trips per total vehicle hours, or the accident rate per 100,000 miles.

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

Specific 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 (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 verbatims)
- Service attributes regarding personnel interactions
  - Courteousness of personnel
  - Timeliness of providing service
  - Quality of information/assistance
  - Resolving problems that arose without unnecessary delay
- Service attributes regarding service efficiency
- Service attribute regarding environment
- Service attributes regarding security and safety
- Service attributes regarding information about the service
- Service attributes about comfort and convenience of use
- Value of the service for costs paid

Case Studies of Relevant Service Industries

Summaries of the five case studies follow.

Case Study of National Temporary Staff Employment Agency

Case Topic: Branch Level Customer Satisfaction Research
Date of Project: 12/96 - Present

General Business Problem
To understand customer satisfaction at the branch level, as the framework for formulating strategic tactic plans to increase customer loyalty.

Objectives of the Market Research Plan
To measure customer satisfaction at the branch level.

The initial sample size for this study was 24,000 per year (i.e., approximately 2,000 per month). In the past year, due to budgetary cuts, interviewing was scaled back from a monthly basis to a quarterly one. Currently, a total of 15,000 interviews per year or 3,750 interviews per quarter are conducted. The customer survey is an eight-minute phone interview.

How was the Market Research Used to Improve Management Decisions and to Develop Performance Measures?
Initial stages of the research provided a general overview of the areas that were primary weaknesses and sources of problems. Monthly, now quarterly, electronic reports provide excellent verbatim feedback to the branches that allow for immediate corrective action. Additional follow-up research is conducted (The Customer Loyalty Study) that provides a more targeted look at the problem incidences noted in the Customer Satisfaction Study.

Special Tools/Products/Methods

An automated fax program was set-up that sent any "critical" (i.e. an interview that received an exceptional low rating for any of the key driver questions) interviews to the branches within 24 hours after completion. These Critical Incident Reports are faxed to both the branch manager and the regional director. The branch manager is required to send a corresponding Corrective Action Report to the regional director within 24 hours of receiving the Critical Incident Report.

Customized electronic report templates have also been developed for cumulative central management review of the nature and location of critical incident reports, and of cumulative and regional customer satisfaction and loyalty measure of a quarterly basis.

Management Organization

A Committee of the company's highest level officials—including the Director of Operations, the Human Resources Director, the Company's Technology Director, and the general and regional branch office directors—manages the Customer Loyalty Program. This committee is responsible for the research design and for developing and reviewing performance measure data.

Performance Measures Developed/Results/Learning Experiences

As a result of the program, specific, individualized performance measures are established on an annual basis for all branches, within regions, regarding expected annual improvements in customer satisfaction and customer loyalty measures.

The critical incident reports and corresponding reports of correction actions filed by branch managers are used by the Regional Directors as the basis for both personnel and resources evaluation.

The Management Committee is currently developing a program to tie revenue measures (profitability) with customer loyalty scores into an annual bonus compensation program for branch managers.

The major lesson learned was that the set-up of such an extensive customer satisfaction process can be very painful for both the research vendor and the client.

Performance Measures Implemented

- Branch-level customer satisfaction levels (10-point scale)
- Branch-level customer loyalty measures (likelihood of using service again)
- Number and nature of critical incident reports (compiled from client survey verbatims)

Case Study of National Pizza Chain

Case Topic: Store Level Customer Satisfaction Research
Date of Project: 12/1995 - 12/1999

General Business Problem

To understand customer satisfaction for the company as a whole and at the store level, and to identify problem areas in front-line personnel-customer interactions.

Objectives of the Market Research Plan

To measure customer satisfaction at the store level.

The research began as a corporate-wide program of 2,500 customer interviews per period. (There were 13 periods in a year, so 1 period = 4 weeks.) After a year, it was targeted at the store level (completing 25 interviews per store). The number of stores included in any given period varied from about 90 to 180, so per-period interviewing ranged from 2,500 to 4,500 interviews. The research was based on a six-minute phone interview conducted with a customer within 24 hours after a pizza was served or delivered.

How was the Market Research Used to Improve Management Decisions and to Develop Performance Measures?

The initial stages of the research provided a general overview of the areas that were primary weaknesses (key driver analysis) and sources of problems. A more targeted look at problem incidence provided excellent verbatim feedback to the stores for immediate action.

Special Tools/Products/Methods

- A direct-dial mainframe was set up so that the company could automatically send sample to the research vendor for next-day calling. An automated system was also established to link dissatisfied customers with the Company's Customer Care Center for processing.
- A Customer Satisfaction Profiler calculator/simulator was developed to show the impact on the *overall* Customer Satisfaction Index (CSI) by driving improvements in key measures such as personnel courtesy and number of minutes to process an order.

Management Organization

The research department was involved in developing performance measures, with no established "buy-in" from top management.

Performance Measures Developed/Results/Learning Experiences

The major learning experience was that overall customer satisfaction measures stagnated after a time, leading to company disinterest and eventual cancellation of the research program.

This lack of continued progress occurred for many reasons, including the lack of high-level management initiative support to enact system-wide change, the inability to incorporate the franchise system in the program, and the inability to tie customer satisfaction levels to profitability.

Corporate goals (i.e., profitability and revenue measures) needed to be established at the unit or store level at the onset. Customer satisfaction results needed to be linked with these goals.

The major driver of overall customer satisfaction was documented by the research to be deficiencies in front-line personnel training. Training was identified as insufficient because documented customer complaints were clustered around not receiving ordered items in their delivery. Follow-up testing determined that this customer complaint was greatly reduced when front-line employees properly used an existing company checklist procedure. Re-training was recommended by the research department to ensure the consistent use of the internal checklist procedure; however, this re-training was never implemented on a company-wide or regional basis.

Performance measures developed and tested in the research were:

- Overall rating of service
- Courteousness of personnel

- Timeliness in providing the order
- Completeness of providing order
- Appearance of service personnel
- Providing assistance and information

Case Study of Furniture Manufacturer

Case Topic: Branch Level Customer Satisfaction Research
Date of Project : 12/98 - 02/2000

General Business Problem

Customer complaints with the company's furniture installation process continued to increase, causing repeat visits. Additionally, research had identified the installation process as a driving factor in the decline of annual customer loyalty measures. Top management recognized that the "installation event" is where a lot of chaos occurs, with tight timeframes and unanticipated problems.

Objectives of the Market Research Plan

To develop a customer satisfaction and quality audit process capable of both evaluating the "installation event" and providing specific, targeted improvement recommendations, that would result in a reduced number of repeat visits and a corresponding increase in customer satisfaction and loyalty levels.

Qualitative research among installation customers was conducted to determine a core set of installation service attributes important to customers. Using this information, a quality audit survey instrument was developed.

A complete telephone census of company installation events was conducted for the year 1999, utilizing this instrument. Each customer interview was conducted with 45 days of the installation event.

How was the Market Research Used to Improve Management Decisions and to Develop Performance Measures?

Critical Problem (Exception) Reports using verbatims from the customer interviews were compiled and submitted electronically to installation managers on a continuous basis. Aggregate quarterly data were collected and reported for each of the individual quality audit performance measures. These performance measure data were integrated in a quarterly report format with customer loyalty measures and revenue and stock data and were published on the company's intranet site as a report card for all employees to view.

Special Tools/Products/Methods

An electronic report card format integrating individual performance measures, customer loyalty measures, and revenue and stock data was developed and posted on the company intranet system as a tracking report card for an important corporate improvement goal.

Management Organization

The corporate goal to improve installation events was set at the highest management level and broadcast to all employees through meetings, newsletters, and the company intranet site.

Performance Measures Developed/Results/Learning Experiences
Substantial improvements in individual performance measures was documented over the 1999 year, repeat visits for installation visits declined, revenues increased and stock declined, while customer loyalty measures increased by 3.4 percent.

Performance Measures Developed and Tracked
- Delivering the order on time according to the schedule
- Delivering the complete order at the scheduled delivery time
- Completing installation correctly the first time
- Being responsive to your needs during the installation and answering your questions
- Resolving problems that arose without unnecessary delay
- Having correct packaging labeling
- Being responsive to your needs and questions prior to the installation
- Resolving problems that arose without unnecessary delay
- Having reasonable delivery lead times

Customer satisfaction measure: "Did the installation 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 company to others?" and "How likely are you to purchase office furniture from this company again?"

Case Study of National Insurance Company
Case Topic: Business Manager Satisfaction Research With Service Representatives
Date of Project: 1997 - 2000

General Business Problem
To understand and fulfill the business-to-business service requirements of large national employers.

Objectives of the Market Research Plan
To be able to rate the functions provided by the 200 customer service teams that sold and serviced health insurance products to large national employers.

This research was designed to help the sponsoring company know where their sales service representatives worked well with their client companies and where a change in service representatives would be appropriate. Additionally, the compensation of the sales and service representatives was both directly and indirectly tied to the results provided by the research project.

How was the Market Research Used to Improve Management Decisions and to Develop Performance Measures?
Ratings made by the customers of the Sales and Service teams and the individuals in each team were used to ascertain individual performance and to identify shortcomings of the teams. A mixture of closed-ended ratings and open-ended responses provided management with a tool that identified star performers and personnel/management issues that needed to be addressed.

Interim reports gave service representatives and their managers an indication as to their strengths and weaknesses. Final reports gave the rating of the individual compared to last year's rating and a ranking (percentile comparisons) against all service representatives. Final reports also provided verbatim comments, which helped service representatives understand their clients' ratings of the services they provided.

Special Tools/Products/Methods
The entire study was conducted over the Internet, although an option to print out the survey and fax it back was also included. Weighting was done based on client company size and importance to the sponsoring company. On-going computerized logs of those who were asked to participate in the survey and those that had actually participated facilitated gentle reminders to non-responders—thereby garnering an 81 percent response rate.

Customized reporting based on a database of responses allowed both the research vendor and the sponsoring company to create and print reports on demand. The two-page reports showed responses and comparisons for all critical questions, clients' verbatim comments, and the bonus that the service representative would receive.

Management Organization
The individual team and summary reports were reviewed by the senior management of both the sales and Customer Service functions, including the Senior Vice-Presidents in these two areas. Trends were monitored and changes in the sales and service representatives were made by the senior management when it appeared that the client was not satisfied with the current sales and service support team.

Performance Measures Developed/Results
As a result of the program, service representatives have been moved around to better meet client expectations. The overall rating program and the feedback that it generates has helped to improve customer satisfaction and loyalty.

Sales and Customer Service representatives can see how their attention to customer needs has positively influenced both their own personal scores and those of the company. This program fits in with the overall company goal of primarily selling to larger, nationally distributed employers over smaller, local employers.

Case Study of National Retailer
Case Topic: Customer Satisfaction Research
Date of Project: 04/2000 - Ongoing

General Business Problem
Customer satisfaction has been identified as a key driver for success. The Customer Satisfaction Survey enables customers to rate the organization and tell them what they need to improve to continue to earn their future business. Through refinement and improvement of the elements of the business, loyal, satisfied customers who can guarantee the long-term success of the organization are created through their repeat purchases and referrals.

Objectives of the Market Research Plan
To develop a customer satisfaction program that helps the organization consistently meet the expectations of their customers.

Outcomes

The benefits of the Customer Satisfaction program are derived through building customer loyalty with attendant opportunities for:

- Increased Customer Satisfaction
- Increased Revenues
- Decreased Cost
- Improved Productivity
- Improved Cost and Price Competitiveness
- Increased Market Share
- Stronger Competitive Posture
- Increased Profits

The most consistent use of the customer satisfaction research was to determine the strengths and weaknesses of retail outlets, and the underlying causes. This assessment was carried out in conjunction with sales data. If customer satisfaction at the outlet is high and sales are high, the outlet and its managers are acknowledged for outstanding performance. If customer measures are high and sales low—the outlet is slated for review of the demographics of its area, in terms of the availability of potential customers. If sales are low and customer satisfaction is also low, the review includes a prioritization of the customer-identified attributes that need addressing, and development of an appropriate action plan for addressing these customer concerns. Such reviews are often the basis for management decisions on outlet expansions or closures, and management compensation, advancement, or dismissal.

Special Tools/Products/Methods

Verbatim comment reports are generated monthly and distributed to key constituencies throughout the organization. These reports, coupled with customer ratings on key questions, help the organization identify problem areas.

Quarterly, products that do not meet customer expectations are identified and provided to the merchant for review.

Performance Measures Developed and Tracked

- Overall satisfaction with the experience
- Ability of the organization to meet expectations
- How closely the experience reflected the ideal experience
- Likelihood to repurchase
- Likelihood to recommend

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3. INTERPRETATION, APPRAISAL, AND APPLICATIONS

CHARACTERISTICS OF EFFECTIVE PERFORMANCE-MEASUREMENT SYSTEMS

Nakanishi and List (***1***) identified a number of key characteristics of effective performance-measurement systems. The following list uses their characteristics as its basis, and adds additional characteristics identified through the literature review, agency interviews, and service industry interviews. These characteristics consist of:

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

The following sections describe these characteristics in detail.

Stakeholder Involvement

There are several key groups of stakeholders that must "buy-in" to the concept of a performance-measurement program in order for the program have long-term viability and usefulness. A number of the documents reviewed found shows that a program initiated without the input and support of all stakeholders is doomed to fail.

The first key group is transit agency management. Ideally, senior management should not only agree to the performance-measurement system, but take the lead in developing and promoting it. As management has control over the resources devoted to measuring and reporting performance, a lack of management support will make it difficult, if not impossible, to adequately measure performance. Further, changes designed to improve performance will not occur without management support.

The second group consists of agency managers and operational employees. Because performance measures reflect the output of multiple individuals, they should not be created in a vacuum or by a few individuals. If agency employees have a chance to participate in the development of the performance-measurement system, they will be more willing to "buy-in" to the program, be more attuned to results, and be more motivated to achieve the agency's goals. Brown (***2***) states that employee and manager buy-in is particularly important when pay incentives are linked to performance measures.

Group number three is the agency's customers, both existing and potential. A performance-measurement program that does not address the aspects of transit service that customers find most important is not particularly useful for identifying areas for improvement that will increase the loyalty of existing customers and attract new customers. Different measures may be required for different types of customers, as expectations may vary by mode, route, or location (Hill, ***3***).

The final group are the members of the agency's governing body. All of the agencies interviewed for this project report at least a selection of the measures they use to their transit board, board of trustees, city council, or similar body. This group requires measures that will help them make policy and financial decisions, and that can demonstrate that their constituents' needs are being met.

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.

Linkage to Goals

An agency's goals should reflect the most important aspects of what it wishes to accomplish. Performance measures are the means of assessing how successful an agency is in accomplishing its goals. CalTrans (***4***) 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. Barnum and Gleason (***5***) 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 is 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

Performance measures should be readily understood by their intended audience. This is particularly true for measures intended to be reported to agency governing bodies and to the public. 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. Brown (***2***) suggests that visually appealing presentation methods, such as graphs that succinctly convey performance results, are important for communicating results to decision-makers. CalTrans (***4***) identifies the need for "routine, readable reports."

Reliability

There are four aspects to the reliability of performance measures: quality data, objectivity, validity, and responsiveness.

The reliability of performance measure results directly depends on the quality of the data used to calculate the measures. Some kinds of data are known with a greater level of accuracy than others; Fielding (***6***), 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. For example, the Capital District Transportation Authority in Albany, NY, needed to train its bus operators on how to use and record farebox information correctly before it could generate reliable performance measures based on those 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 also be consistent between reporting periods, so that accurate comparisons can be made between different periods of time.

Objectivity is the second aspect of reliable performance measures. Those involved in developing performance 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 (or will avoid make the agency look bad), but rather on the basis of which measures will accurately and fairly assess how well an agency is achieving its goals.

The third and fourth aspects of reliable performance measures are validity and responsiveness. A valid measure is one that really measures the concept of interest. A responsive measure is one that changes in a meaningful way when the concept of interest changes, without being overly sensitive to changes, and is not biased by changes elsewhere in the system.

Variety of Measures

The performance measures used by an agency should reflect a broad range of issues. For a variety of reasons, particularly because of federal reporting requirements and the relative ease of obtaining data, many agencies have focused on measures reflecting financial performance and ridership. This narrow focus has meant that critical aspects of performance that are important to customers and the community at large have often not been sufficiently addressed.

In addition, measures are needed to assess past, present, and future performance. For example, some measures inform about what has happened in the past—for example, the average number of transit riders per month for the last six months. Other measures describe what is currently happening—the number of riders for the current month. Still others serve as indicators of what may occur—if riders' satisfaction level has declined recently, the number of riders may drop over the next several months. Including lagging, current, and leading measures in a performance-measurement program provides balance.

There is some linkage between providing measures addressing a broad range of issues, and providing measures addressing different timeframes. Kaplan and Norton (*7*) note that financial measures express past performance, while measures of customer satisfaction and organization innovation drive future performance.

Schiemann and Lingle (*8*) 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). Qualitative measures assess how customers feel about the service provided. These measures may be measured quantitatively (e.g., a customer rating of bus reliability on 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 with the need to avoid having so many measures that users are overwhelmed, leaving them unable to sift through the data to find the key drivers of service quality. Brown (*2*) describes this as choosing between "the vital few measures and the trivial many," and suggests an upper limit of 20 measures that any given level of an organization should try to track. Schiemann and Lingle (*8*) 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 (Brown, *2*).

Indexes that combine several measures into a single measure can be used to reduce the number of measures that are reported. However, they pose a danger that important trends in the component measures may be masked within the overall index measure (Brown, *2*).

Level of Detail

The measures used within a performance-measurement system need to be detailed enough to allow an 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, 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 (Brown, *2*).

The resources available to an agency may constrain the level of detail at which certain measures can be evaluated. Cambridge Systematics (*9*) recommended that agencies first identify ideal measures that match their goals at the desired level of detail, and then, if needed, identify surrogate measures that could be used in the interim.

Flexibility

Goals change over time, as do external factors. A performance-measurement system should provide the flexibility 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, in order to encourage managers and employees to find ways to continually improve their performance. Unrealistic targets will cause the credibility of the program 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.

The desire to continually improve performance should be tempered by the amount of effort required to achieve that performance increase. If the effort required to achieve the next increment of improvement is excessive, agencies may wish to consider whether maintaining the existing high level of quality is sufficient, and whether resources would be better allocated to improving other areas.

Using different targets for different service types was something that a number of surveyed agencies were either already doing, or expressed a desire to do in the future. Different service types often serve different goals and will often require different targets, or even different measures. For example, expectations for *boardings per hour* would be different for an express route than for a local crosstown route. At a statewide level, Barbour and Zerrillo (***10***) described the New York State DOT's performance-measurement work, and how NYSDOT divided New York's 110 transit systems into groups based on mode, service type, and fleet size to provide more accurate classifications of performance standards.

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. The Los Angeles County MTA's Chief Administrative Analyst for Transit Operations Support noted during his agency's interview 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 to overcome in developing the current program were (1) certain departments' "ownership" of data, and their reluctance to share it, and (2) 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 CTA 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.

Other Considerations

Researchers are split on whether employee financial incentives should be tied to performance measure results. Nakanishi and List (***1***), for example, take the position that performance-measurement programs "should be able to motivate employees without the threat of discipline or enticement of rewards, especially if the results are publicly posted on a consistent basis. In many cases, there is not absolute correlation between accomplishments and the performance measure, and it would be unfair to discipline based on such indicators." Schiemann and Lingle (***8***) caution that even when good performance measures are chosen, implementing a poorly conceived incentive program may create unintended side-effects, as employees work to meet short-term goals that maximize their financial reward, but in a way that hinders the organization's long-term success. In a worst case, employee and management criticism of a poor incentive program may lead to the entire performance-measurement program being derailed. They quote Bethune (***11***), who stated "…even if you define success right but you still measure and reward the wrong thing, your employees are going to figure out what you are measuring and give you that."

On the other hand, both Barnum (***12***) and Hartman, et al. (***13***) found that about two-thirds of the agencies they surveyed offered some kind of incentive program. The most common areas tied to incentives were safety, absenteeism, and driver performance (i.e., Roadeos). Barnum noted that successful pay incentive plans displayed "a clear and dependable link between performance objectives and employee reward."

GAPS IN EXISTING TRANSIT PERFORMANCE MEASURES

It is not an exaggeration to say that someone at sometime has developed a performance measure for almost anything. The challenge in identifying gaps in existing transit performance measures was not so much in developing new measures. Rather, the challenge was in tracking down performance measures that had not been widely publicized in transit literature, but that could be important components of a transit performance measurement program.

This section is organized into broad categories of measures—availability, service monitoring, community, travel time, safety and security, maintenance and construction, economic, and capacity—developed by the project team. Within each of these categories, major gaps are described, and new measures and/or subcategories described to fill these gaps. In a few instances, measures that were included in the original performance measure summary were dropped from further consideration, where the original assessment of the measures found them to be not particularly useful. Some measures were also moved to new categories, to better reflect their use. *[Web Document note: the material in this section refers to the project's Performance Measure summary, which is not included in this Web Document, but is available on loan from TCRP, and will also be incorporated into the final Guidebook.]*

Availability Measures

No major gaps were identified in the availability measures. A distinction has been made, though, between spatial availability measures and community accessibility measures: measures that look at area served are now entirely listed in the availability category, while those measures that look at the number of people or jobs served are now entirely listed in the community category.

One new family of measures is proposed: *fleet composition.* This family includes the *percent trips (vehicles) wheelchair accessible* measure previously identified, and adds two new measures: *percent of fleet composed of low-floor buses,* and *percent of bus fleet equipped with bicycle racks.* The former measure addresses ease of access for passengers who have trouble climbing steps to board a vehicle (whether due to age, disability, strollers, etc.). The latter measure addresses service availability to passengers who incorporate a bus trip as part of an overall bicycle trip. These measures could also be used to track progress towards an agency goal of being fully wheelchair accessible, 100% low-floor, or fully bicycle accessible.

Additional new performance measures in this category consist of:

- *Number of fare media sales outlets.* 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 fare structure, or have exact change available. It can also save time for regular customers who would otherwise have to use ticket machines or make a longer trip to one of a smaller number of sales outlets. The ability to purchase fare media on the Internet, through the mail, and at mobile sales outlets should be considered, as should on-board purchase of multiple-ride types of fare media.
- *Percent of (longer-headway) routes scheduled to clock headways.* 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 extra vehicles required to serve a route. At short headways

(under ten minutes), service is frequent enough that customers do not need to consult schedules, and the need to schedule to clock headways is minimal.

- *Number of bicycle rack spaces/lockers at transit stops/stations.* This is a measure of accessibility for people who would like to use their bike to access transit, but do not need the bike at the other end of their trip. Because most bus stops will not have the passenger or bicycle volume to justify installing racks or lockers, counting the number of racks or lockers is preferable to calculating the percentage of stops so equipped.

The *ratio of number of stops to number of service hours* was dropped from further consideration, as it did not appear to have a strong connection to utilization, or capture other characteristics that might influence the attractiveness of transit service.

Service Monitoring Measures

A number of new service monitoring measures were identified, although no major gaps were found. However, one new measure, *action achieved,* is never really identified as a measure in the literature, but is used all the time by agencies in reporting their success in implementing new programs over the past year. A similar measure, *percent of goal achieved,* measures success for multiple-year (or other time period) programs. Many of the bullet-point accomplishments in the Brampton Transit annual report included in the literature review fall into one of these two measures (e.g., opened new transit center, took delivery of eight new buses, etc.).

Other new measures are:

- *Lost service.* A new family of measures, consisting of *percent lost hours* (previously identified) and *lost time* (new). The latter is the revenue hours lost from when a vehicle ceases service (due to a mechanical breakdown or other reason) to when it resumes or is replaced in service.
- *Equipment Reliability.* A new family of measures, including:
    - *Average percent of time elevators/escalators are in service* (previous)
    - *Average number of stations per day with out-of-service elevators/escalators* (previous)
    - *Wheelchair lift failure.* The number of times a person is unable to board or alight due to a mechanical failure of the wheelchair lift.
    - *Percent of time ticket machines in service.* A measure of passenger delay in buying tickets. This can be particularly irritating to passengers if they miss a bus or train because of long lines at the machines that are working.
- *Percent of fleet cleaned daily.* This is a measure of vehicle cleanliness that can be derived from maintenance records, rather than passenger environment surveys, and thus is proposed to be called out separately.
- *Feature existence.* This is a measure of whether something (e.g., a telephone information line) exists or not. It has two values, yes or no, and is the type of measure that can be used in summary tables comparing various aspects of different services or systems.
- *Headway deviation*—the number of minutes 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 boarding data to estimate the amount of extra time passengers spend waiting for transit vehicles.

There are a number of service monitoring performance measures that appear can only be quantitatively measured via passenger environment surveys, at least cost-effectively. These would include such measures as *destination sign accuracy, announcement audibility,* etc. Rather than call these out separately in the performance measure summary, is proposed to include these in the general categories of *passenger environment (bus)* and *passenger environment (rail)* and to discuss them in detail in the body of the Guidebook, in a section describing different types of surveys.

One measure was dropped, *excess wait time,* as other measures of headway regularity appeared to be easier to calculate, easier to explain, and/or were better indicators of regularity.

Community Measures

The project team, as well as the panel, identified a number of potential performance measure gaps within this category. New subcategories to address these gaps are described below.

Trip Generation

This subcategory looks 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. Measures in this subcategory are:

- *Number of automobile trips eliminated.* A commonly used measure to describe transit's role in reducing automobile pollution, reducing 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 trips. However, the same argument could be made about highway capacity improvements, that providing more capacity may induce trips that otherwise would not have been made.
- *Change in vehicle-miles traveled.* This 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 the first measure apply to this one. Trip length data are required to calculate this measure.
- *Number of trips not made in absence of transit.* 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.* This can be measured three ways: overall (the traditional mode split, which generally does not favor transit outside the largest cities), in areas served by transit (which compares trip-making patterns in areas where riding transit is available as an option), and in areas served by transit, at times service is provided (which introduces a temporal component to determining when transit is an option). Both the Florida TLOS Indicator and the Transit Availability Index can be used to help determine adjusted mode splits, and both have found significant differences between reported mode splits and the percentage of people using transit when it is a realistic option.

Demographics

Measures in this subcategory 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. Note that the listing of these measures *does not* imply that these are the only types of customers that transit serves; merely that these are useful indicators of the ridership potential of *these kinds* of potential transit users. Other types of areas (e.g., neighborhoods) can be substituted for "service area" in these measures.

- *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*

Welfare-to-Work Accessibility

In addition to the *welfare-to-work accessibility index* identified previously, the following additional measures could be used in this category:

- *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*

Community Economic Impact

This subcategory looks at ways that transit impacts the economic health of the community as a whole, as opposed to transit's impact on personal finances (covered in the next subcategory). Three measures previously identified are included in this subcategory (*percent of state/regional gross product represented by transit, economic costs of pollution caused/alleviated by transit,* and *public expenditures by mode*). New measures consist of:

- *Tax revenues to state and local government due to transit*
- *Amount lost annually to vehicle accidents in the absence of transit*
- *Amount of unemployment compensation expenditures 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*

Personal Economic Impact

This subcategory looks how transit costs impact personal finances. One previously identified measure is included, *percent of household income used for transit,* along with two new ones:

- *Difference in transit and automobile out-of-pocket costs.* This measure can reflect the daily, monthly, or annual savings that transit users achieve by taking transit in cities with 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.

- *Average fare*—a useful factor to help determine appropriate peer agencies for comparisons

Efficiency

Measures in this subcategory measure 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 community investment. Some of these measures could also easily fall into the "economic" category, but are included here because they are tied to community goals or funding requirements, or because they are often used in peer comparisons. Measures include:

- *Local and state transit funding per capita*
- *Return on transit investments*
- *Percent of reverse commute trips made by transit*—a measure of how efficiently vehicles that are already required for peak-direction service can be utilized in the reverse direction.
- *Percent of private sector contribution to transit construction/renovation project*
- *Percentage of revenue from business activities (excluding fares)*—a measure of how well an agency can supplement fare revenue with other types of business revenue (e.g., advertising revenue, lease revenue, etc.), to minimize public subsidies or to minimize passenger costs.

Communications

These measures address how successfully transit agencies are able to communicate with the citizens of their community. Not all of these citizens may be regular transit users, but they may vote on transit funding issues, or have friends or family members that use transit service. A lack of information (whether because it is not provided, or because of a barrier created by language or disability) can also serve as access issue—if someone doesn't know how, when, or where to use transit, it's very hard for them to become a user. Measures in this subcategory are:

- *Number of residents with positive transit perceptions in a community survey*—an indicator of how successful an agency's "image" marketing efforts are, as well as an indicator of whether an agency should work to improve its community image before presenting a transit funding package to voters.
- *Number of residents with knowledge of transit service availability within their community*—an indicator of how successful an agency's "information" marketing efforts are.
- *Information provision for persons with disabilities*—for example, the percentage of brochures available in large-print or Braille formats.
- *Information provision for persons for whom English is not their primary language*—for example, the number of languages spoken by customer-service agents, or the number of languages that "how-to-ride" material is provided in.

Other Measures

New measures that can be placed into one of the existing community subcategories are:

- *Number of housing units created near transit stops, stations, and terminals* (accessibility)
- *Percent of special-needs populations with access to paratransit services* (accessibility)
- *Transit route distance vs. air distance between neighborhoods and activity centers* (community cohesion)—this can measure, for example, the barrier effect of highways, railroads, canals, and other manmade and natural features, assuming a reasonable standard exists for *route directness*.
- *Percent of TANF clients using welfare-to-work transportation whose job tenure is at least X years* (employment impact)
- *Transit-related air/water pollution per vehicle-mile traveled/1,000 boardings/capita* (environmental impact)
- *Air quality at transit stops/stations/terminals vs. air quality in other areas* (environmental impact)
- *Amount of air/water pollution eliminated or reduced due to transit* (environmental impact)
- *Congestion Burden Index* (mobility)

Measures eliminated, due to lack of clarity and/or usefulness, were: transit supply and cost of transit services vs. total cost of business operations.

Travel Time Measures

Travel time measures are well defined. However, two additional useful measures were identified:

- *Travel time variability.* This can be an important customer satisfaction issue, and relates to *on-time performance* and *headway regularity.* It measures the variation in the length of a customer's trip, which relates to (1) how often a person gets to their destination by their expected time, and (2) how much extra time persons must allow in order to reasonably ensure that they get to their destination by a certain time. This is generally measured after-the-fact because, unfortunately, the tools do not yet exist to accurately predict the variability that would occur from a given set of circumstances.
- *Difference in overall passenger times.* This can be used as a service design criterion. For example, Chicago's new bus service standards allow deviations to existing routes only when it can be shown that the time saved by the passengers served by the deviation (for example, by not having to walk as far to a transit stop) outweighs the additional time incurred by passengers already on the bus. This measure potentially be used to justify increasing stop spacing, by showing an overall travel time benefit to passengers.

Safety and Security Measures

This category was one where gaps were apparent. Further investigation revealed that safety performance is often measured through safety reviews where, for example, checks are made to ensure that various safety-related procedures are being followed. While these checks are very important to an agency and its passengers, they do not necessarily result in useful performance measures (most of the items being reviewed use yes/no types of measures, and the goal is to meet each one). Examples are provided in the literature review in Appendix A.

It is proposed to describe safety reviews within the body of the Guidebook (along with other types of surveys), rather than to try to develop individual measures for the kinds of things addressed by these reviews. The panel is encouraged to consider how much detail it desires in this section—should the material be self-contained, or should readers be referred to other, more detailed sources. For example, should the description of customer satisfaction surveys, passenger environment surveys, or safety reviews provide a digest-level description, or should readers be referred to appropriate reference material elsewhere.

Outside the realm of safety reviews, several new measures were identified that focus on safety and security issues:

- *Number (percent) of vehicles with specified safety devices.* This measure incorporates security cameras (previously identified), and adds such things as intercom systems, emergency alarms, and AVL equipment (to facilitating locating a vehicle).
- *Percent positive drug/alcohol tests*—derived from random testing of employees in positions that can directly impact passenger and employee safety. A high incidence of positive tests can indicate the potential for safety problems.
- *Number of incidents of vandalism*
- *Employee work days lost to injury*
- *Number of traffic tickets issued to vehicle operators*
- *Percent buses exceeding speed limit*—obtained through speed checks conducted by field supervisors equipped with radar units.
- *Number of station overruns*—number of trains whose front stops more than a specified distance past the end of the platform. This can be an indicator of a need for improved operator training, or that the braking rates assumed in the system design (particularly for emergency braking distances) are not being achieved (for example, due to rain or snow, or the wearing down of the train's wheels).
- *Number of fires*—measured by location—stations, vehicles, guideway—and potentially by severity.

Maintenance and Construction Measures

Maintenance was another area where gaps were apparent. In particular, Maze (*13*) provided a useful source of maintenance-related measures. Those measures that have either a cost or labor component are included in the "economic" category. Measures that have neither of these components are included in this category. New measures consist of:

- *Road calls*—converted into a family of measures, including *number of road calls, miles per road call,* and *road calls per bus/bus model/failure type per month*.
- *Maintenance work orders per bus model vs. the total fleet*—an indicator of inherent reliability problems with particular models of buses.
- *Actual spare ratio vs. scheduled spare ratio*—how many buses planned to be available to fill in for buses during the day actually were available?
- *Average life of major vehicle components*—useful for a preventative maintenance program, to replace major components before they fail

- *Average age of major vehicle components*—another component of a preventative maintenance program, to help schedule and budget future work
- *Percent of vehicles with functioning climate-control systems*—this is also a service monitoring measure, but one that specifically relates to the maintenance program.
- *Number of defects reported by operators*—an efficiency and preventative maintenance indicator.

In addition, *vehicle cleanliness* was removed as a maintenance indicator, as it is typically measured through a passenger environment survey. Another measure, *percent of trains cleaned after each trip*, was substituted.

Economic Measures

Despite the perception that economic measures are the most well-developed set of measures used by transit agencies, three major gaps were identified. The first area was specific to transit: fleet maintenance performance and maintenance program effectiveness. However, the other two areas are also applicable to many other industries: measures relating to employee relations and employee productivity, and measures relating to risk management. These subcategories are addressed in the following sections.

Fleet Maintenance Performance

Measures in this subcategory relate to the cost of maintaining a vehicle fleet. The previously identified measure here is *vehicle miles per gallon* (*labor hours per vehicle hour* is moved to administrative performance). New measures are:

- *Maintenance labor cost per vehicle/vehicle mile*
- *Maintenance material cost per vehicle/vehicle mile*
- *Maintenance consumables cost per vehicle/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 part inventory*
- *Maintenance labor costs vs. material costs*

Maintenance Program Effectiveness

This subcategory includes measures of the number of mechanics, the number of work orders completed and on backlog, and the time required to complete repairs. The previously identified measure is *mechanics per 1,000 revenue (vehicle) miles*. New measures consist of:

- *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 preventative maintenance vs. total corrective maintenance*—how often is a major problem identified before it causes a vehicle to break down while in service
- *Total labor hours spent on preventative maintenance vs. total labor hours*
- *Maintenance labor hours backlogged*
- *Total number of maintenance inspections scheduled vs. inspections performed, per week*
- *Percent of preventative maintenance inspections performed within the prescribed interval*
- *Average miles past the prescribed interval that late preventative maintenance inspections occur*
- *Average labor time required to make corrective repairs*
- *Monthly number of stock-outs*
- *Average length of time parts on back-order*

Employee Productivity

This subcategory includes measures that reflect how much overtime is being worked, and measures that will indicate problems with absenteeism and tardiness. These are issues that are present for any business, not just transit. As labor costs are a major component of an agency's overall operating costs, controlling these costs will help the agency's bottom line. Identified measures are:

- *Staff tardiness rate*
- *Staff absenteeism rate*
- *Pay-to-platform hours*
- *Total regular and overtime labor 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*

Employee Relations

Measures here reflect how happy employees are with their work, how much they feel that their opinions are listened to and acted upon, and how well the organization seeks to improve their professional skills. The four measures in this subcategory are:

- *Staff turnover rate*
- *Number of employee suggestions*
- *Number of employee suggestions implemented*
- *Number/percent of employees trained*—in a particular area, whether it is how to communicate with unhappy customers, CPR training, or any other kind of training.

Risk Management

These measures track how much money the agency is spending on various types of preventable losses:

- *Vehicle liability losses*—costs to repair damage to transit vehicles, or to other vehicles damaged by transit vehicles
- *General liability losses*—for example, due to customer injuries
- *Property losses*—damage to transit agency property, or damage to other property caused by transit vehicles
- *Employee liability/workers compensation payments*
- *Other liability losses*—less common types of losses, such as environmental liability (cleaning up spills), contractual liability, civil rights liability, sexual harassment liability, and director/officer liability.

Other Measures

The administrative performance subcategory was modified by removing *spare ratio* (moved to maintenance) and *average fleet age* (duplicated in service monitoring), and adding *labor hours per vehicle hour* (moved from fleet maintenance performance). Cost effectiveness measures were modified by passenger mile as well as by passenger. *Operating (farebox recovery) ratio,* the fare revenue divided by operating cost, was added to the *cost effectiveness* subcategory. Several interviewed agencies identified that they had minimum ratios that were set by local or state governments.

Capacity Measures

No gaps were identified in this category. The *Transit Capacity and Quality of Service Manual* extensively covers bus, train (line), person, and station/platform capacity issues. The capacity measures proposed for the Guidebook will be re-examined to see if they need to be less generalized (e.g., *bus capacity*, *train/line capacity*, and *ferry capacity* in place of *vehicle capacity*).

PERFORMANCE MEASURES IN ADA PARATRANSIT AND OTHER DEMAND-RESPONSIVE TRANSIT SYSTEMS

Introduction

Developing a guidebook for transit performance requires assessing performance in a variety of different transit modes, including fixed-guideway, fixed-route, and demand-response service. Performance measures and standards can be used to assess a transit agency based on efficiency, effectiveness, and its role within the community it serves, among many other factors. Most agencies strive to perform well, and to increase the amount of service provided, the quality of service provided, and the positive impact that transit has on the citizens it serves. Superior transit service should lead to financial stability and improved service, and allow service growth.

Demand-response service is somewhat different than 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-response service limit or affect growth.
- Demand-response requires a significantly different service delivery approach since individuals' trips must be scheduled and drivers' routes change constantly.
- Improving service quality increases demand for service, but without the economies of scale achievable by other modes (e.g., ridership increases, but the cost per passenger does not decrease significantly).
- Growth in demand often results in significant financial stress for a transit agency, possibly resulting in limiting demand-response service or reducing service levels in other modes.

As a result, applying performance measures to demand-response 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-response environment.

Providing practical and useful transit performance measurements and standards for demand-response service therefore requires an approach that recognizes the significant service differences which exist in demand-response service and seeks a strategy consistent with those differences. Nevertheless, ADA Complementary Paratransit and general demand-response service also have significant areas of similarity with other transit modes.

ADA Complementary Paratransit

ADA complementary paratransit service exists in urban areas and since 1990 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 a result of a disability.

Regulatory Constraints

Transit systems are required to adhere to a variety of regulations contained primarily in 49 CFR Part 37, Subpart F, dated September 6, 1991. Many of the requirements set what are in effect general or specific performance standards to which transit systems providing ADA complementary paratransit must adhere to.

Table 10 details some of the impacts that ADA regulations can have on performance measures, particularly in terms of measures needed to assess compliance with the ADA.

Table 10. Impact of ADA Regulations 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 with 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 approach of agency in assessing eligibility. Key measures are percentage of applicants approved and conditional versus unconditional eligibility.

Issue	ADA Guideline	Impact on Performance Measures
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.	Measure no-shows and missed trips as gross number and percentage of total trips provided. Measure 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 3/4-mile on each side of route except areas outside of its jurisdictional boundary	Minimum service area is determined.
Next Day Reservations *Subpart F 37.131b*	Service shall be scheduled and provided to 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 call-takers must process reservations.
Pickup Time Negotiation *Subpart F 37.131b*	Trip cannot be required to be scheduled more then 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 a 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 also equal 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, and 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.
Subscriptions Trips *Subpart F 37.133*	Subscription service is allowed - cannot exceed 50 percent at a given time of day unless there is excess capacity	Monitor level of subscription service unless there is excess 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 should have standards and measures to ensure that they are complying with regulations. Second, the requirements of ADA are not necessarily characteristic of 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. Because such techniques are prohibited in ADA Paratransit, demand can escalate, requiring the use of alternative demand management techniques, which can have less success.

Alternative 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:

- Eligibility processes that include prescreening applicants, interviews, functional assessments, mobility assessments, and cognitive assessments. The intent is 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, percent of conditional approvals*, and trend analysis. Cost-benefit analysis of the cost of the assessments versus the cost savings in reduced potential ridership can also be measured.
- Travel training 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 need to train them. Additional performance measures could examine whether the savings in ADA paratransit trips equals or exceeds 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 only limited by the amount of seats and standing spaces and the trip length of passengers. Productivity levels are expected to be higher in fixed-route than in ADA complementary paratransit and general demand-responsive service.

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

- Routes are variable and unpredictable from day to day.
- Only one person typically boards or alights at a given location.
- Distance and time between pickups is higher than on fixed-route service.
- Service is often provided to residences, which requires travel into subdivisions and on lower-speed streets.
- Persons with disabilities require additional time to board.

Limited productivity means that providing service per person is much more expensive for demand-responsive service than for fixed-route service. ADA complementary paratransit service normally costs eight to twelve times as much per passenger as fixed-route and fixed-guideway service in large urban transit systems.

Service Delivery Approach

Demand-responsive service requires different resources than fixed-route service. Many of these resources require functions not required in fixed-route service. 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 that include schedulers and/or an automated scheduling system are needed.
- Dispatching demand-responsive services is significantly more labor-intensive than dispatching fixed-route services. Contact with passengers and lost drivers, and confirmations of pick-ups require a lower ratio of dispatchers to drivers than in fixed-route service.
- Schedule changes are more frequent and unpredictable than in fixed-route service. Dispatchers and drivers are required to more frequently adapt to changing circumstances.
- Individuals apply to determine if they are qualified to use the ADA complementary paratransit service, and their applications are assessed in some manner.

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 growth usually means that a higher percentage of seats are filled a higher percentage of the time and service is more cost-effective and efficient. Demand-responsive service growth means additional pick-ups and drop-offs are performed, while the number of seats filled may not significantly change. As a result, more service hours are needed to provide the additional service. Growth in demand is combined with the reality that the cost per trip increases as a result of increases related to the Consumer Price Index (wages, benefits, fuel, etc.). Both types of cost increase result in compound cost growth for paratransit that, in an environment of finite financial resources, 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 county to focus on efforts to control demand and, 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. Increases in service demand 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 that 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 really desirable and, if not, what level of service quality actually is best.

The ADA regulations, productivity limitation, 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 operating health. Performance measures and standards should be tailored to the unique operational and regulatory environment in which ADA complementary paratransit operates.

General Demand-Responsive Service

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 with a significantly different mission than 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 the fleet of a general demand-responsive fleet. No pattern or practice of discrimination should exist with a person with disability's ability to receive a trip versus an individual without apparent disabilities to receive the same trip.

Many other guidelines of the ADA are not applicable since, in the general demand-responsive system, everyone is receiving demand-responsive service. ADA guidelines not applicable include the following:

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

The absence of these constraints allows an agency to ration demand more effectively and easily than can an ADA complimentary paratransit service. Given this level of flexibility, the measurement of service has some significant similarities with fixed-route service.

Agency Mission

General demand-responsive paratransit service is designed for the entire public. Often, demand may be 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, it is normally the only or primary means of public transit mobility in 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 mobility. Service options with general demand-responsive service are where and how much service to provide yet, with only one mode of transit service, there are few tradeoffs required with other modes of service.

Service Delivery Approach

General demand-responsive service requires different resources than fixed-route service. Many of these resources require functions not required in fixed-route service. Different functions require performance evaluations that may not be applicable to fixed-route services. Examples of these differences include:

- Mechanisms must be in place for advance trip reservations or same-day trip reservations.
- Schedules can change quickly. An ability to adjust to changes is needed.
- Dispatching demand-responsive services is significantly more labor-intensive than dispatching fixed-route services. Contact with passengers and lost drivers, and confirmation of pick-ups requires a lower ratio of dispatchers to drivers than in fixed-route service.

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

Growth in Demand for Paratransit

The same factors that influence growth in demand for ADA complimentary paratransit services, described previously, also influence growth in demand for general demand-responsive service.

Assessing Appropriate Performance Measures

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, all are public transit services designed to meet various goals. The eight general categories of performance measures identified in the TCRP G-6 performance measure summary document are applicable to both types of service.

Availability

Service availability in ADA 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 that seem vital for ADA complementary paratransit include the following:

- *Service area and coverage:* What is it and does it meet or exceed the ADA?
- *Span of service:* What are the hours of service and do they meet or exceed the ADA?
- *Service hours:* Total service hours will measure the effort required to provide service.

- *Revenue hours:* Productivity is often calculated based on this measure.
- *Service denials:* It is necessary to review the existence and extent of this capacity constraint.

All of these measures would also be significant for general demand-responsive paratransit service. Additional measures significant for general demand-responsive service include the following:

- A *transit orientation index* would be an important measure for a general demand-responsive service that was experiencing capacity issues to see if fixed- or flexible-route service may be a better service option in a portion of its service area.
- *Access (response) time* would be another important measure, especially if service was significantly rationed by the agency.

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. However as one rural demand-response system manager once said, "no one wants to be the person in the middle seat in the back of the van."

Knowing where an agency stands in 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 indicates that a sufficiently high level (never specifically defined) of late trips can qualify as an impermissible capacity constraint for complementary paratransit. One means of improving system efficiency—increasing system speed—can result in poorer on-time performance. Reliability and efficiency can be conflicting goals and an agency will need to determine what is the appropriate balance and if or how it can be achieved.
- *Missed trips*, which are those trips that are more than one hour late, can be used in both ADA complementary paratransit and general demand-responsive service as a reliability measure. 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. This measure is most appropriate in systems serving more than 100 trips a day, as customer phone access becomes an issue. Missed phone calls should be generally monitored as an accessibility issue related to obtaining the provision of ADA service. The *percentage of calls on hold excessively long* would be a similar measure.
- *Customer response time* to complaints and inquiries is an important means of determining responsiveness and should be considered as a reliability responsiveness measure.

Community Measures

Community measures can be used to indicate and measure the potential value of the demand-responsive service and ADA 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 macroscopic impacts. However, other interested agencies (e.g., the state government or a state transit association) might have the resources to measure these impacts.

- *Welfare-to-work accessibility* could be a significant general demand-responsive measure since it would show that transit was providing the means for Temporary Assistance for Needy Families (TANF) recipients to access work.
- *Economic impact* would be valuable, because it provides an understanding of the positive role of transit in community development.

ADA paratransit's role in community measures is most appropriately viewed as a component of the overall benefits and impact of transit service delivery by the entire agency, rather than being viewed separately.

Travel Time Measures

Travel time is a significant measure of the quality and effectiveness of transit service as it compares it to other modes. Specific significant measures include:

- *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. Many transit agencies overlook that travel times on paratransit that are significantly shorter than fixed-route service encourage use of more costly ADA complementary paratransit. Additional use results in negative financial impact for transit agencies.
- *System speed* is important to measure in two respects. First, the scheduled average system speed should be known. Second, the average system speed that is actually provided should be known. 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 both services in terms of passenger confidence and control of liability and insurance costs. The one significant measure in this area is *accident rate*.

Maintenance and Construction Measures

The effectiveness of an agency in maintaining vehicles would be the 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 call rate*, as it measures the reliability of vehicles and the effectiveness of the preventative 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 observed result of demand and. 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 how much it directly costs to provide service. *Cost per vehicle hour* is a common measure of efficiency, and can be used to determine the marginal cost of providing an additional hour more or an additional hour less of service.
- *Cost effectiveness* measured by the *cost per passenger* is a critical measure based on the level of service productivity plus the cost per hour of service. Cost per passenger is normally significantly higher in ADA complementary paratransit and general demand-responsive service. Therefore, increases in the number of passengers result in increases in cost. In contrast, passenger increases in fixed-route services often result in lower costs per passengers due to the many economies of scale that exist in fixed-route service—until the passenger loads in revenue vehicles reach capacity.
- *Productivity* is a key component of the cost of providing service. Demand, service area size, scheduling resources, scheduling parameters, cancellations, no-shows, and traffic congestion can all impact the level of 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 demonstrates that closely monitoring trip no-shows and late cancellations (what the ADA calls "a pattern of missed trips") can be useful in controlling service cost and enhancing service effectiveness. General demand-responsive service can also be negatively impacted by these kind of missed trips, which waste planned service resources.

Capacity Measures

None of the measures cited in this area could be considered critical for measuring ADA complementary paratransit and general demand-responsive service.

Summary

ADA complementary paratransit and general demand-responsive service have significant differences in how they operate, and this results in some significant differences in the more critical service measures. ADA complementary paratransit service is shaped strongly by the existing regulatory constraints. Its role, while critical, is not the primary transit service that a agency delivers (other than paratransit-only agencies), and these agencies will wish to consider the impact of this service as it effects their primary service. When provided, general demand-responsive service is normally an agency's primary service, and there is more latitude in its delivery than exists in ADA complementary paratransit service.

PROCESS FOR A COMMUNITY- AND CUSTOMER-ORIENTED PERFORMANCE MEASUREMENT PROGRAM

Although a key product of the TCRP G-6 project will be a detailed menu of performance measures that agencies will be able to select from, it is important not to focus on individual measures to the extent that the reasons for implementing a performance-measurement program are forgotten, and the process for applying the measures ignored. Hill (*3*) noted that many states that had implemented performance-measurement programs found that the consensus-building process required to develop the program was invaluable. As a result, she recommended emphasizing the performance-measurement process, not just the product.

The agency interview process identified that economic performance and service monitoring measures were widely used; safety and security, and maintenance and construction measures were often used; and that availability, community, travel time, and capacity measures were rarely used. In contrast, many researchers and organizations (e.g., Brown (*2*), Cambridge Systematics (*9*), Carlquist (*14*), Victoria Department of Infrastructure (*15*), the Federal Transit Administration (*16*), Hill (*3*), and Kaplan and Norton (*7*)) have identified the need to address the community and/or customer perspective.

The element that is missing from many existing transit agency performance-measurement programs, is not simply that community- and customer-focused measures are rarely included, but something more fundamental: a lack of a clear connection between what is being measured and the agency's goals and objectives. If a transit system sets out to serve its customers and community well, and develops its performance-measurement system around these objectives, appropriate community- and customer-focused measures will naturally be a product of the program.

The remainder of this section describes the key steps involved in developing a community- and customer-focused performance measurement program. Figure 2 illustrates these steps in the form of a flowchart.

Define the Goals and Objectives

There are two related sets of goals and objectives to consider: (1) the goals of the performance-measurement system—what is it trying to accomplish?—and (2) the agency's overall goals and objectives.

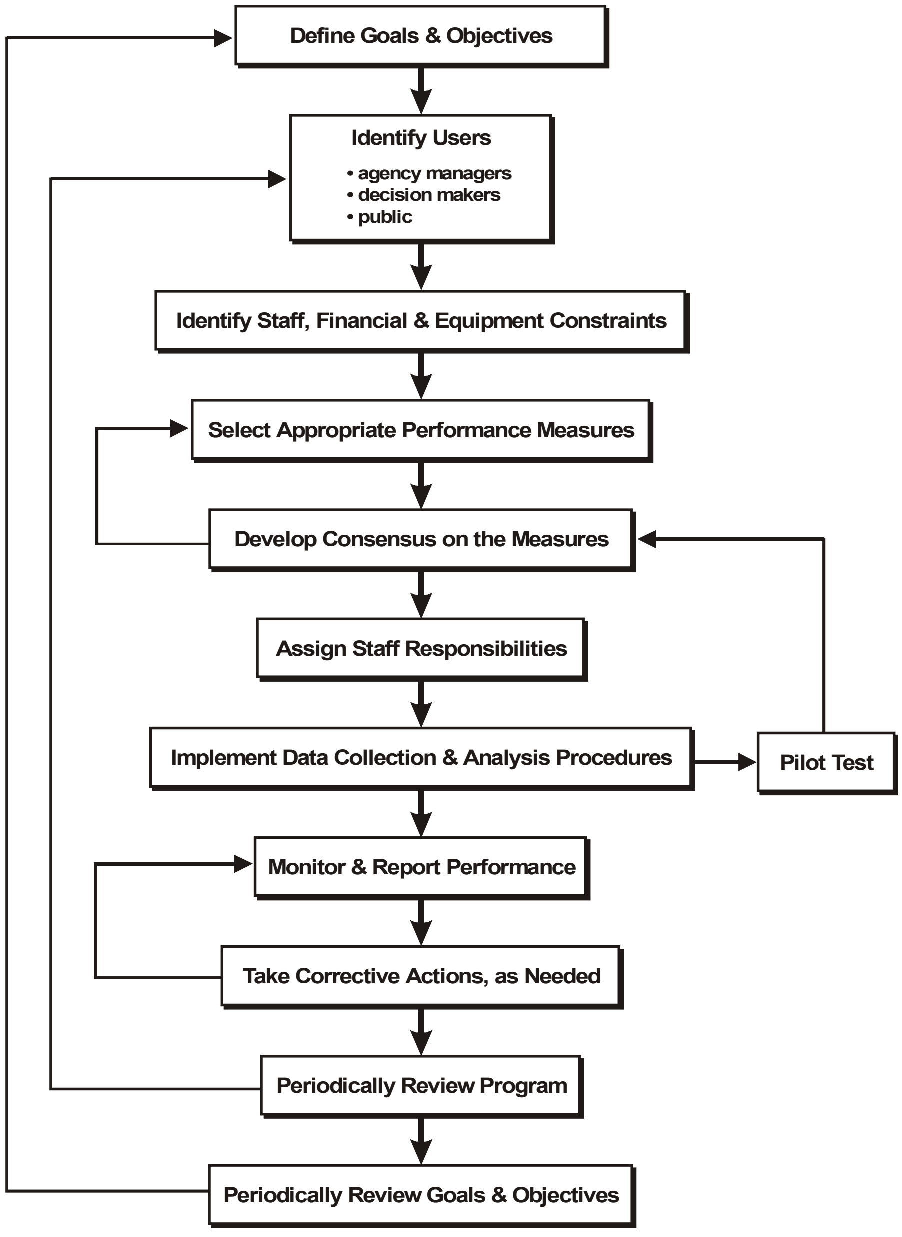
The first set of goals is more internally focused, and requires input from a variety of agency stakeholders, including transit management, agency managers and operational employees, and the agency's governing body. The must be clear consensus among these stakeholders on the need for the program and how it will be incorporated into the agency's decision-making process. Without clear and continuing leadership from key stakeholders that the program should be an integral part of the agency's activities, there is little point in continuing with the remaining steps, as experience shows that programs lacking this consensus quickly wither and die.

The second set of goals—the agency's overall goals and objectives—has both an internal and external focus. If an agency wants to be able to determine how well it is serving its customers and its community, it needs to include input from these groups when it develops its goals and objectives, to make sure that what the agency sets out to accomplish matches well with what its customers and community expect. Focus groups, customer and community surveys, and working with an established Citizens Advisory Committee are all techniques that can be used to develop this input.

If a performance measurement program is not well integrated with the system'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 the creation of a performance measurement program. If an agency already has a set of goals and objectives, but has not reviewed them recently, it would be worthwhile to review them to make sure that they are still appropriate.

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, while other agencies have retained the more traditional process-oriented goals and objectives which evaluate the internal efficiency of the agency—how well the agency is able to utilize its resources in providing transit service. A balance is required that will allow an agency to serve its customers and community as best as it can, given its available resources.

Figure 2. Performance-Measurement Program Process



Identify Users

Potential users of a transit performance-measurement system include managers and staff from different parts of the transit organization, the agency managers, decision-makers (e.g., a transit board or funding body), and the public. When developing performance measures, transit systems should be cognizant of the intended audience for that measure. In general, performance measures intended for use by the general public and decision-makers should be relatively simple, easy to understand, and broad; whereas performance measures intended for internal system evaluation can be more obscure, convoluted, and focused. However, there should be consistency between lower-level measures used by internal agency departments, and higher-level measures reported to the public and decision-makers (Brown, *2*), so that the entire agency remains focused on the agency's goals and objectives.

Identify Staff, Financial, and Equipment Constraints

The operating characteristics of a particular transit property play a huge factor in shaping the nature of a system's performance measurement program. A large urban transit system is naturally going to have more resources available than a small, rural transit property. Consequently, a transit system should consider all relevant system constraints when designing their 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 always revisit and expand upon the existing performance measurement program to include additional performance standards or categories.

Potential constraints that should be considered include the following:

- *Staff resources*—How many agency staff members are available to compile performance measurement data and develop reports? Will staff be available to conduct field data collection? Do staff have particular skills (e.g., database development, GIS training) that would provide flexibility in the kinds of measures selected? The number of measures incorporated in a program should be directly related to the number of staff dedicated to the program.
- *Financial resources*—The benefits derived from improvements made as a result of the performance-measurement program should outweigh the cost of the program. Trying to measure too much, too soon, will not likely prove to be cost-effective. Will money be available to hire additional staff, if needed, or to fund data collection efforts or new equipment?
- *Equipment resources*—What kinds of equipment (e.g., APC, AVL, GIS, etc.) does the agency have in-house, or have access to via partnerships with other agencies such as MPOs? If an agency doesn't have GIS software, staff trained to use it, and the necessary supporting GIS data, it should seriously consider whether (1) it should select measures that don't require the use of GIS, or (2) make the needed investments in GIS or outside contractors to allow the desired measure to be used.

Existing constraints should be balanced with the need to develop measures that do a good job of measuring agency goals and objectives. The *National Transportation System Performance Measures* report (Cambridge Systematics, *9*) recommends a two-step process to achieve this balance. In the first step, an initial set of desired measures is developed that is not constrained by data availability, data analysis, or resource issues. After this set of measures is identified, then the agency should ask questions about how difficult it would be to use each measure, whether new costs to develop the data needed for the measure are likely to be offset by other benefits, and whether there are surrogate measures that could be used in the interim.

The Chicago Transit Authority (CTA) and Nashville MTA (NMTA) both have plans to convert to various ITS technologies to assist in their data collection efforts. These plans are in place because both transit systems realize they have access to insufficient information to effectively monitor and improve system performance. CTA indicated that they are currently able to monitor the performance standards in the maintenance categories much more effectively than more traditional performance measures such as on-time performance or passengers per mile. This is not particularly surprising considering that 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.

In contrast, Tri-Met, which has a well-established automated data collection program, has found that the challenge with an automated program is figuring out what to do with all of the data that are collected—both in terms of the types of data and the volume of data. One week's worth of automated bus arrival and passenger boarding and alighting records at the timepoint level can exceed the number of records that can be imported into a single spreadsheet page, for example. Developing a useful data storage system that allows historical data to be easily accessed and analyzed is an important consideration with automated data collection programs.

Select Appropriate Performance Measures

Prior to selecting specific performance measures, it is recommended that transit systems establish general, overarching categories for their performance measurement program. These categories should be directly linked with the system's goals and objectives. Depending on the intended scope of the performance-measurement program, one or more measures can be selected within each category, to best suit different users of the program. For example, if one of an agency's goals is to provide its customers with reliable service, a top-level measure that might be reported to decision-makers and the public is systemwide *on-time performance.* However, internal departments might track other measures that relate both to their function and to the overall agency goal, to help identify specific department actions that could be taken to improve overall agency performance. For example, the maintenance department might track *road calls*, the operations department *missed trips*, and the scheduling department *travel time variability*. As mentioned above, the measures initially selected should be compared to the agency's constraints, in order to achieve a balance between how well the measure tracks a particular a goal, and the amount of resources required to calculate the measure.

Not all measures need to be continually tracked. Some measures can be developed as design guidelines, so that if the design guideline is met, the agency can be reasonably confident that the goal related to that guideline is being met. For example, MDTA in Miami, Florida (***17***) 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 planning to evaluate 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. The Chicago CTA (***18***) 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).

Once specific measures are identified, performance standards should be established for each measure. These standards should neither be 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 (*2*) states that standards should be "challenging, worthwhile, and achievable"—the 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.

The agencies interviewed used five main ways of developing standards:

1. *Comparing performance 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 prioritize the poorest-performing routes. However, 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.

2. *Comparing performance to a baseline average.* This is a variation on the first system, in which 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 the first system, in that 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 waste 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. Further, there is no incentive to improve—simply maintaining the baseline condition is more than sufficient.

3. *Developing standards internally.* Under this system, transit 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 system allows customer and community issues to be considered and—if the standards are updated on a regular basis—allows for continual performance improvement. One potential flaw with this system is that the experience of other agencies is not taken into consideration. Eccles (*19*) 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.

4. *Comparing performance to typical industry standards.* This system builds off 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 standards in the transit literature, and applies an average or typical standard to its own operations. This has the advantage of being at least somewhat defensible—the standards weren't pulled out of thin air, but are comparable to what others are doing—but

fails to consider either other agencies' special circumstances that caused them to adopt a particular standard, or the agency's own circumstances.

5. *Comparing performance to peer agencies.* Under this system, an agency identifies other agencies with similar conditions (e.g., city sizes, level of government support, fare levels, goals and objectives, cost of living indexes, or other similar criteria), and determines how well those agencies are performing in the categories to be measured. Standards are based on the average values of the peer agencies for given measures, or alternatively, some percentile value. This system 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.

A combination of these approaches would appear to be ideal. Developing a baseline is useful for tracking performance improvements over time. Comparing performance to peer agencies allows one to know which areas one is especially excelling or deficient in. Internal review of standards allows local conditions and objectives to be considered.

An agency should strongly consider developing different standards for different types of services and different times of day. The Champaign-Urbana MTA identified separating university services from other types of services as a need for its program. The Denver RTD identifies seven classes of service (local-CBD, local-urban, local-suburban, express, regional, demand-response, 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 (LAVTA) 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 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 which allows the system to evaluate its performance in each fiscal year as either "meeting the standard" or "not meeting the standard". Table 11 presents the fixed-route performance standards and objectives for the LAVTA fixed-route network.

Table 11. 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%[1] 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.
Service should be operated 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 PM 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).

Develop Consensus on the Measures

While it certainly is not as important to have broad community support for a performance measurement program, compared to having community support for a transit system's goals and objectives, a transit system should make a concerted effort to develop consensus on the major aspects of the performance measurement program among the key stakeholders involved. The Champaign-Urbana MTA (CUMTA) requires board approval of its performance measurement program before the program can be implemented. This approval process exposes the performance measurement program to further scrutiny and also ensures consensus among CUMTA's governing board. Ideally, a transit agency would also hold a public forum to provide the general public an opportunity to provide feedback on the performance measurement program.

Assign Staff Responsibilities

In order to implement an effective performance measurement program, the various components of the program must be assigned to specific staff members or positions. 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. Data collection, data analysis, and data reporting are the three main responsibilities to be assigned among agency staff. At the Chicago Transit Authority (CTA), the 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.

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

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, they simply do not receive the bonus for that particular reporting period. Australian agencies (***15***) also apply contract penalties when standards are not met and, when performance is particularly poor, require holders of monthly or longer passes to be provided some sort of compensation.

Implement Data Collection and Analysis Procedures

Performance standards are only as good as the data collection capabilities of the transit system. Many of the transit systems interviewed for this project indicated that technological improvements have substantially improved their ability to collect information and monitor systemwide performance. Tri-Met utilizes automatic vehicle location (AVL) systems and automatic passenger counters (APC) to monitor on-time performance and daily ridership figures. In fact, Tri-Met indicated that they are frequently in a state of information overload since they are not accustomed to having access to so much information. Consequently, 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, transit systems need to have sound data collection and analysis procedures and methodologies in place in order to successfully monitor performance.

At the Capital District Transportation Authority (CDTA) in Albany, NY, 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 record farebox information correctly.

Conduct a Pilot Test

Once the initial framework of the performance-measurement program has been developed, it is prudent to conduct a small-scale pilot test of the program to make sure that everything is working as intended. The pilot test allows potential problems with the program, such as difficulties with collecting data for particular measures or timeliness of reporting, to be identified and corrected early, prior to the full roll-out of the program. This helps ensure that the introduction of the program on an agency-wide level occurs smoothly. If the pilot test identifies that changes may be needed, the agency should review both the measures it has selected and its data collection and analysis procedures, and make appropriate changes.

Monitor and Report 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 performed monthly standards reporting, while others preferred quarterly, bi-annual, or annual reporting. Every month, Nashville MTA 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 due to 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 needs of its passengers.

A performance-measurement program that includes a diverse set of measures may require different reporting periods for different groups of measures. Availability measures, for instance, generally only need to be reviewed at the time service changes are being considered, which may be as infrequently as once a year. Some service monitoring measures, such as *number of complaints*, could be reported much more frequently (at least monthly). In general, the more frequent the reporting period, the more effort that is required for the program; however, more frequent reporting allows quicker identification of problems and potentially quicker responses to the identified problems.

The Los Angeles County MTA indicated that the primary obstacle to regular performance measurement reporting was data acquisition. The agency had internal issues accessing the data 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 it has become a critical component of the decision making process.

The Tri-County Metropolitan Transportation District of Oregon (Tri-Met) conducts telephone surveys of the general public approximately twice a year. Tri-Met 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 Tri-Met'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 in and year out, Tri-Met is able to get a sense of how public opinion changes over time. For example, Tri-Met's most recent survey effort in August 2001 revealed that public support for the system's light rail network had increased anywhere from 5-14% depending upon the line in question. Tri-Met can utilize this information to influence the policy making process and shape the direction in which the agency moves.

Take Corrective Actions as Needed

Transit agencies must have policies and procedures establishing how they are going to make adjustments to their service provision based upon the information collected through performance measurement. In fact, this is quite possibly the most important step in the whole performance measurement process. After collecting, evaluating, and reporting the performance measurement data, transit agencies are then faced with the question of what they should do to improve overall performance.

For any route performing at 50% above or below the system average, CUMTA staff analyze the route data and make recommendations to improve route performance. This route-by-route analysis occurs on a quarterly basis. NMTA utilizes a similar approach to identify corrective action; however, a route must be performing at or below 60% of the system average to be reviewed. NMTA implements service adjustments based upon this review process every six months.

Once a particular action has been identified by the agency to address a particular issue identified through the performance measurement program, the agency needs to continue to track the measure to identify the impacts of that action. If subsequent measures indicate that performance has not improved to the desired level, the agency would then repeat the process by analyzing the reasons for the sub-par performance, identifying a new action to take, and tracking the results of that action.

Periodically Review the Program

In order to maintain an effective performance measurement program, transit agencies should periodically review the overall program performance. It is recommended that these reviews be completed annually or semi-annually. CTA evaluates and updates its performance measurement program every year. Conversely, Tri-Met has not substantially changed their performance measurement program in over 12 years. Tri-Met 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 Tri-Met, transit agencies should continue to monitor their programs to ensure that they are still getting the job done. Reviewing standards is particularly important to avoid institutional complacency—standards that are being met should be periodically revised upwards to encourage continued improvement, as long as the revised targets are realistic and the benefits achieved will outweigh the costs of achieving the higher performance level.

Periodically Review Goals and Objectives

As part of the 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 both their own priorities and the community's priorities, and to reorganize their goals and objectives accordingly. 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. If the goals and objectives receive a significant overhaul, it is possible that the performance measurement program may require the same.

LAVTA reviews and updates its goals and objectives every two years as part of the completion of the Short Range Transit Plan (SRTP). This constant revision of the goals and objectives ensures the system of maintaining its vision and keeping pace with the constantly changing transportation needs of the community. While many transit agencies may not consider it necessary to revisit their goals and objectives so frequently, this process should be completed at least every five years.

4. DETAILED GUIDEBOOK OUTLINE

INTRODUCTION

- Guidebook purpose
- How to use this guidebook

1. MEASURING PERFORMANCE

- Why measure performance?
- Performance points-of-view
    - Customer
    - Community
    - Operator
- Importance of customer satisfaction
- Characteristics of an effective performance-measurement system
    - Stakeholder acceptance
    - Linkage to goals
    - Clarity
    - Ease of data collection
    - Data reliability/program objectivity
    - Variety of measures
    - Number of measures
    - Level of detail
    - Flexibility
    - Standards and targets matched to service type
    - Realism of standards and targets
    - Data timeliness
    - Report availability and presentation
- Service industry lessons
- Performance measure uses
    - Service monitoring
        - Current service
        - Trends
        - Before-and-after studies
    - Economic performance
    - Management
        - Risk management
        - Maintenance
        - Employee satisfaction
    - Communications
        - Goal achievement
        - Customer charters
        - Public reporting
    - Community benefits
        - Mobility
        - Outcomes
        - Environment

    - Service design standards
        - New service guidelines
        - Bus route design
        - Service planning
- Case studies of successful programs
    - Lansing, MI (customer satisfaction focus)
    - Livermore, CA (small system focus)
    - Honolulu, HI & Tampa, FL (large city ADA demand-response focus)
    - St. Lucie County, FL (general demand-responsive system)
    - Denver, CO (large system focus)
    - Baltimore, MD (innovative PM techniques focus)
    - San Diego, CA—SANDAG (MPO focus)
    - New York, NY (comprehensive PM program)
    - New South Wales, Australia (innovative service contractor focus)
    - Sydney, Australia (linking measures to goals and objectives)
    - European Union (international focus)

2. DEVELOPING A PERFORMANCE-MEASUREMENT PROGRAM

- Introduction
- Process (listed steps to be simplified)
    - Generate management support
    - Identify users and stakeholders
    - Define goals and objectives
    - Identify constraints
    - Select performance measures
        - Ideal measures
        - Interim measures
    - Develop consensus
    - Test and implement program
    - Monitor and report performance
    - Integrate results into agency decision-making
    - Review and update program
- Special considerations
    - ADA paratransit
    - General demand-responsive transit
    - Rural transit
    - Service contracting
- Core performance measures
    - Fixed-route
    - Demand-response
- Example application

3. PERFORMANCE MEASUREMENT TOOLS

- Performance measure categories
  - Availability
  - Service monitoring
  - Community
  - Travel time
  - Safety and security
  - Maintenance and construction
  - Economic
  - Capacity
  - Paratransit
  - Comfort
- Types of measures
  - Individual measures
  - Ratios
  - Indices
  - Levels of service
- Data sources, collection techniques, and applications
  - In-house
  - National Transit Database
  - Other agencies
    - Demographic data
    - Traffic data
    - Infrastructure data
    - GIS data
    - Transportation planning models
  - AVL/APC/farebox data
  - Field data collection
  - Customer satisfaction surveys
  - Safety reviews
  - Passenger environment surveys
- Setting performance standards
  - Comparison to the annual average
  - Comparison to a baseline
  - Trend analysis
  - Self-identified standards
  - Comparison to typical industry standards
  - Comparison to peer systems
- Reporting results

4. TRANSIT PERFORMANCE MEASURE MENU

- Instructions
- Selection menus
- Performance measure descriptions
- Performance measure index

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APPENDIX A: ANNOTATED BIBLIOGRAPHY

This appendix presents the literature review compiled as part of the TCRP G-6 project, *A Guidebook for Developing a Transit Performance-Measurement System.* To assist the reader in quickly identifying the key aspects of each document, the following format is used to present the following summary information for each document:

- **Context.** The reason the document was produced.
- **Applicability to G-6 Project.** A series of checkboxes indicate the topic areas that the document applies to:
  - performance-measurement program descriptions;
  - characteristics of effective performance measures or measurement systems;
  - performance measure examples;
  - market research;
  - performance reporting;
  - applications of technology; and
  - other topics not covered by the above categories
- **Transit Systems Evaluated.** The specific transit system(s) where data were collected, case studies made, and/or measures or programs described.
- **Transit Modes Considered.** A series of checkboxes indicating the mode(s) that the document's material applies to. If the material applies to public transit in general, rather than specific modes, the "All" box is checked, rather than the boxes for each mode.
- **Service Contracting Addressed?** Does the document cover the usage of performance measures for transit service contracting (yes or no)?
- **Performance Measures Identified.** Performance measures described in the document are listed according to the following working categories:
  - community-based measures;
  - transit availability;
  - comfort and convenience;
  - service delivery;
  - service offered/utilization;
  - economics/productivity;
  - vehicular capacity; and
  - speed and delay.

If a very large number of measures are presented in a particular document, specific measures are not listed; instead, the word "yes" appears for that category, indicating that the document presents numerous measures for that category. Specific measures are summarized in detail as part of the Task 3 working paper.

- **Summary.** A synopsis of the key findings and results of the document being reviewed. In general, the longer the summary, the more relevant the document appears to be to the TCRP G-6 project's work.
- **Comments.** Editorial comments made by the reviewer(s) about points or conclusions raised in the documents, or additional information relating to the document's topic that is

not presented in the document itself. Not all documents will have comments associated with them.

The documents summarized in the annotated bibliography are indexed by author and subject. These indexes are in Appendix B.

Allen, William, and Lewis Grimm

"Development and Application of Performance Measures for a Medium-Sized Transit System"
Transportation Research Record 746
National Academy Press, Washington, DC, 1980

Context: This report is the result of a survey of transit performance measures for the DART.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: The Delaware Authority for Rapid Transit (DART)

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? No

Performance Measures Identified: See the summary.

Summary: This short paper offers a brief discussion of performance standards and measures, noting that such measures are often used for two separate purposes: funding and management. It emphasizes that measures are most useful when comparing routes within a system and that care should be taken for peer group measurement using performance measures. The paper also is clear that care should be taken to use the measures in the right context and with the right level of detail so that they do not produce erroneous results.

The standards and measures the paper uses to evaluate the DART system were fairly average. It was found that schedule adherence was closely related to load factors, maintenance standards, and other operating conditions such as layover time provisions. Since DART is a medium sized system (100 buses total), the author points out that this study is unique in that it demonstrates the feasibility for performance measurement on medium-scale systems. It concludes by saying that the performance measures used for the DART study are valuable for both operator and laypeople, and that to be used correctly, such measures must have a considerable amount of planning and forethought in the measures and standards used. The final conclusion is that it is preferable for measures and standards to be initiated at the local level, so that they are more sensitive and provide accurate pictures of what is really going on.

Association of Train Operating Companies

ATOC Bulletin
ATOC, UK, June 2001

Context: Public information on rail operators' performance in the UK

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Twenty-five train operating companies (TOCs) in the UK

Transit Modes Considered: Commuter rail

Service Contracting Addressed? No

Performance Measures Identified:

- *Community-based:* Number of national rail inquiry calls answered (target: 90%)
- *Service offered/utilization:* Train miles on a typical weekday, by train category (intercity, interurban, commuting, rural, and urban); passenger journeys
- *Economics/productivity:* Total rail earnings; revenue

Summary: This bulletin by the ATOC gives some performance indicators. The SRA (Strategic Rail Authority) publications give additional indicators for the UK train operators, such as reliability and punctuality indicators.

Comments: This bulletin gives the following comments on the Punctuality and Reliability Standards:

- Performance is reported by TOCs every four weeks as part of their franchise obligations.
- The process for measuring performance is independently audited.
- Punctuality and reliability data trigger season ticket discounts if performance falls significantly below one or both measures.
- The moving average figures are derived by weighting the performance of each reported service group by the number of trains run.
- Prior to April 1996, punctuality was calculated on a basis of 0 to 6 or 0 to 11 minutes. From April 1996, this has changed to 0 to 5 or 0 to 10 minutes for each service group.

See the reviews of SRA publications for more details.

Axelson, Peter W., Kathleen M. Wong, and Julie B. Kirschbaum

"Development of an Assessment Process to Evaluate Sidewalk Accessibility"
Transportation Research Record 1671
National Academy Press, Washington, D.C., January 1999

Context: Development of a process for evaluating the accessibility of sidewalks (particularly in terms of the ADA)

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: All, in a very general, supportive sense

Service Contracting Addressed? No

Performance Measures Identified:

- *Comfort & convenience:* Sidewalk accessibility (in terms of sidewalk quality)

Summary: This paper presents a methodology for quickly gathering information about the ADA accessibility of pedestrian facilities. The process is a yes-no checklist-based approach designed to identify sidewalk features (e.g., grade, cross slope, sidewalk width, surface type, number of driveway crossings, number of curb ramps, street width, presence of parking, presence of pedestrian signals, and crosswalk type) that do not comply with the ADA.

Comments: The paper is not concerned specifically with transit stops, although the elements of the ADA that apply to transit stops could be added to the authors' methodology and "sidewalk accessibility" as used in this report could become a measure of transit's convenience. (It is not a measure of transit availability in this paper.) The methodology does not define levels of service or provide a way of measuring a pedestrian's perception of the sidewalk quality other than the number of non-conforming elements located along a particular section of sidewalk.

Baca, Mauricia, M. Glomski, J. Rappaport, and G. Russianoff

What Did They Say? A Survey of Subway Car Announcements
Straphangers Campaign, New York, NY, 1997

Context: The Straphanger's Campaign believed that subway car announcements were often difficult to hear and problematic and decided to measure the percentage of acceptable announcements. This report describes the survey of subway car announcements and results generated by 57 volunteers who made 9,088 observations on 2,420 subway trips.

Applicability to G-6 Project:
- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: NYC Transit

Transit Modes Considered: Heavy rail

Service Contracting Addressed? No

Performance Measures Identified:
- *Community-based:* Customer-oriented measure of subway car announcements
- *Comfort & convenience:* Subway car announcements

Summary: The report states that communicating with the public, especially if there is a delay or incident, is important. According to the results of the survey, more and clearer information is needed on subway cars. The surveyors listened for announcements when there was a delay of two or more minutes or when there were service changes. More than a third of the time, the announcement was garbled or inaudible. Fifty percent of announcements that were audible and understandable were not useful. This meant that 67 percent of the time there was no announcement or an announcement that did not meet passenger needs. Station and transfer information provision was also rated. Line-by-line results were presented. The recommendations made by the authors are (verbatim):
1. Ban useless announcements right now.
2. Convene an internal task force immediately.
3. Make sure riders get announcements about short delays, which often fall through the cracks.
4. Require daily tests of each car's public address system—and fix broken speakers quickly.
5. Urge riders to inform conductors if speakers are not working.

Balog, John N., John B. Morrison, and Mark N. Hood

"Integration of Paratransit and Transit Services: Importance of Vehicle Transfer Requirements to Customers"
Transportation Research Record 1571
National Academy Press, Washington, D.C., 1997

Context: The authors focus on the desirability of customers with disabilities transferring to fixed-route service or transferring on fixed-route service. The paper looks at the preferences of persons with disabilities as it relates to transfers.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☒ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Customer preferences in New York, Dallas, Madison, Bridgeport, Orlando, and San Mateo

Transit Modes Considered: Urban demand-response (general public & specialized)

Service Contracting Addressed? No

Performance Measures Identified:

- *Comfort & convenience:* Transfers between fixed-route and paratransit, transfers in fixed-route service

Summary: This study examines through the analysis of three studies how negative the attitude towards transfers between vehicles is for persons with disabilities. The importance of this question is to gauge the effectiveness and impact of transfers. What is clear from the report is that requiring transfers in paratransit trips reduces the perceived quality of the service.

Comments: This research would be corroborated with the experience of Pierce Transit in Washington State, where ridership levels dropped 20 percent when individuals were required to transfer. Few agencies have implemented paratransit transfers, despite being cost-effective, because they tend to be logistically complex, politically unpopular, and generate a lot of complaints. While this study does not directly touch on paratransit performance standards, it points to the difficulty of lowering service quality in order to produce more cost-efficient service, even when agencies are facing significant financial constraints.

Barbour, Leland, and Robert Zerrillo

"Transit Performance in New York State"
Transportation Research Record 857
National Academy Press, Washington, D.C., 1982

Context: This paper expands on past research (see the Zerrillo, Keck, and Schneider review) to examine further refinements in the New York State DOT's performance measurement program.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: All NYSDOT-funded systems

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified:

- *Service offered/utilization:* Revenue passenger per revenue capacity hour, revenue passenger miles per capacity hour/capacity mile, revenue passengers per employee hour, revenue passenger miles per employee hour
- *Economics/productivity:* Revenue capacity hours per employee hour, revenue capacity miles per employee hour, revenue vehicle hours per vehicle, revenue vehicle miles per vehicle, operating cost per capacity mile/capacity hour, operating revenue per operating cost, operating cost per revenue passenger mile, deficit per revenue passenger mile

Summary: This paper details the third year of the NYSDOT's pioneering performance measurement system. The major difference between the first two years and the year considered in this article was that NYSDOT shifted from evaluating individual transit systems equally to dividing the analysis based on fleet size, mode, and service type. This division allowed for different, more appropriate operating standards to be implemented for each system type instead of holding systems of different size and type to the same standards. Additionally, the NYSDOT developed a set of service quality measures that complemented the traditional economy, efficiency, and effectiveness measures. These additional measures took the form of service quality, reliability, and safety indicators. However, despite mentioning the addition of these new performance measures, the authors give little detail about them and focus instead on the effectiveness of dividing the systems into the groups described above.

Comments: This study updates the study from the previous year, also reviewed for this project. (See the Zerrillo, Keck, and Schneider review.) The major difference is that this paper focuses on dividing the 110 systems in NYSDOT into separate groups based on mode, service type, and fleet size. This division allows for more accurate classification of performance standards for each type of system.

Barnum, Darold

"Use of Incentives to Attain Specified Performance Standards in Collective Bargaining for Mass Transit"
Synthesis of Transit Practice 13
Transportation Research Board, Washington, D.C., 1987

Context: This paper evaluates the effectiveness of using incentive pay plans for unionized transit employees to raise the quality of transit services.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Two systems were evaluated as case studies: the Metropolitan Transit Authority of Harris County, Texas, and the Mass Transportation Authority of Flint, Michigan.

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified:

- *Service delivery:* Number of absences, number of unexcused absences, number of miss-outs, number of chargeable accidents, number of avoidable accidents, number of on-the-job injuries, vehicle miles per road call, on-time performance percentage, passenger trips, passenger revenue, operating ratio

Summary: This paper examines the characteristics of successful pay incentive plans and their role in improving transit employee performance. It offers detailed suggestions for the design, implementation, and evaluation of such plans. It found that successful plans were ones that displayed a clear and dependable link between performance objectives and employee reward. If employees did X (improved on-time ratios, for example), then they were consistently rewarded with Y. Another important criterion found was that the benefit must clearly outweigh the effort necessary to achieve it. Other characteristics of successful plans were high rewards offered, unambiguous performance indicators, union participation in designing the plan, managerial commitment to the plan, and rewards offered for individual performance increases as opposed to shift- or division-wide rewards.

It was found that 67 percent of transit agencies had existing pay incentive programs in place. The most often rewarded performance indicator was attendance, with driver performance (Roadeo) and vehicle safety ranking second and third, respectively.

Barnum, Darold, and John Gleason

Drawbacks Inherent in Currently Used Measures of Mass Transit Performance
Prepared for U.S. DOT, Washington, D.C., May 1980

Context: This paper was written to address some of the shortcomings of standard performance measures, particularly addressing several effectiveness measures that the authors say should more accurately be called efficiency measures.

Applicability to G-6 Project:
- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: No specific agencies were evaluated.

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified:
- *Service delivery:* Cost per passenger, vehicle miles per operator
- *Service offered/utilization:* Passengers per bus hour
- *Economics/productivity:* Cost per vehicle hour

Summary: This is an excellent paper that succinctly addresses shortcomings in performance measure ratios such as cost per passenger and cost per vehicle hour. The authors argue that effectiveness and efficiency criteria are often confused, resulting in inaccurate measures of both.

One example given is that of the cost per passenger ratio. Cost per passenger ratios measure the total costs of operating a system divided by the total number of passengers serviced. A low cost per passenger ratio is traditionally assumed to measure an effective system. However, the authors argue that this performance measure can be deceiving and needs to be considered within the context of the goals of the system. For example, a high cost system that moves a high volume of passengers would have a higher cost per passenger ratio than a cheaper system that carries fewer passengers. If the goal of the system is to move as many people as possible, than the first system would be more "effective" at achieving this, even though it has a higher cost per passenger measure. Thus it is extremely important to clarify what the *goals* of the system are in order to make sense of these numbers. The measures alone do not communicate meanings such as "effective" or "efficient," which are relative terms that are given meaning by the objectives of a transit system.

The authors make a very strong point that numeric performance measures can often be deceiving in nature and can result in a false impression of the effectiveness or efficiency of a system. They urge careful consideration of the meaning of each measure and advise against using strictly numeric performance measures to evaluate system functionality.

Benn, Howard

"Bus Route Evaluation Standards"
TCRP Synthesis of Transit Practice 10
National Academy Press, Washington, D.C., 1995.
http://nationalacademies.org/trb/publications/tcrp/tsyn10.pdf

Context: This TCRP document revisits the 1984 USDOT report titled *Bus Service Evaluation Methods* and "provides supplemental material for use by the transit industry in the area of route level service delivery."

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Survey of 111 transit agencies

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? No

Performance Measures Identified:

- *Community-based:* Population density, employment density
- *Transit availability:* Network connectivity, route directness
- *Comfort & convenience:* Maximum number of standees, passenger complaints
- *Service delivery:* Use of clock-faced schedules, span of service
- *Service offered/utilization:* Passengers per hour, passengers per mile, passengers per trip
- *Economics/productivity:* Cost per passenger, subsidy per passenger
- *Vehicular capacity:* Standees versus no standees
- *Speed & delay:* Missed trips

Summary: This report is based upon an extensive survey effort of more than one hundred transit properties of varying size and scope. The author categorizes many of the performance measure results by the size of the transit system's bus fleet (e.g., 51 to 200 buses, 201 to 500 buses, etc.). This provides transit agencies with a better sense of how they compare with their peer agencies with regards to specific performance measures. For every performance measure reported, the author provides a summary of the value of the measure and the environment in which it is best utilized. For example, the author reports that clock-face headways are most frequently utilized by smaller transit systems with bus routes operating on headways greater than 10 to 12 minutes.

Comments: The appendices contain much of the raw data collected through the survey effort.

Biemborn, Edward, A. Horowitz, J. Schuetz, and G. Zejun

Measurement of Transit Benefits
Prepared for the Federal Transit Administration
U.S. DOT, Washington, D.C., 1993

Context: This report was written to examine both the economic and non-economic value of transit systems to passengers and communities and to identify methods to evaluate such benefits.

Applicability to G-6 Project:
- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☒ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: No specific systems were evaluated.

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified:
- *Community-based:* Benefit Tree Analysis, interviews, surveys
- *Economics/productivity:* Disutility measures (the sum of various indices such as automobile riding time, transfer penalties, vehicle ownership costs, etc.), net consumer surplus, time savings in person-minutes traveled

Summary: This report offers a framework for analysis of the non-economic benefits of transit, in addition to general economic evaluation. The primary tool used for non-economic analysis was the "Benefit Tree" (also called a path diagram), which creates a branch cause-and-effect diagram for all of the possible impacts that transit could have. The four main branches of the tree are "Alternative," "Travel," "Land-Use," and "Supply." Each of these branches then has multiple sub-branches that explore the possible benefits to each scenario. "Alternative," for example, is broken into "Long Term Option," "Unusual Occurrences," "Recreational Riding," and "Independent Living," each of which is analyzed further.

Each sub-branch of the Benefit Tree that could be analyzed economically was done so. Methods used were varied, ranging from Elastic Demand Equilibrium, Disutility of Travel, Deterrence Functions, Benefits Assessments, etc., to Air Pollution Reduction via pounds of carbon dioxide emitted.

This report is quite comprehensive in scope and necessarily lacks specific methodological detail. It does, however, present a thorough explanation and example of the use of Benefit Trees to explore the non-economic value of transit. It is a policy paper that offers a good introduction to the varied approaches to performance measurement, but aside from Benefit Tree Analysis, offers little specific techniques.

Comments: This report was written to highlight the non-economic benefits of transit and was presented to the FTA in 1993.

Brown, Mark

Keeping Score: Using the Right Metrics to Drive World-Class Performance
Quality Resources, New York, NY, 1996

Context: Brown presents a performance measurement system that is based, in part, on Kaplan and Norton's Balanced Scorecard method, but goes further and explores indicator weights and development of indices.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: None

Service Contracting Addressed? No

Performance Measures Identified:

- *Community-based:* Customer-satisfaction index (not transit, though)

Summary: Brown describes all aspects of a performance measurement system. According to Brown, the characteristics of an effective performance measurement system are:

- *"Vital Few Versus Trivial Many"* – Brown writes that organizations should have no more than 20 measures. Choosing the key metrics linked to the success of an organization is important.
- *Linkage to Vision, Values, and Key Success Factors* – Identifying the keys to the organization's success and then selecting performance measures (PMs) that measure those factors are another characteristic of an effective PM system.
- *Metrics Should Focus on the Past, Present, and Future* – Most measures focus on the past or the present. Brown states that future measures may predict the success of an organization.
- *Metrics Should Be Linked to the Needs of Customers, Shareholders, and Employees*
- *Metrics Should Flow Down to All Levels and Should Be Consistent* – Individual units and functions may have measures unrelated to the organization's overall measures. Measures should be set at the top and then flow down to the next lower level and so forth such that metrics for Level 5 will lead to metrics for Level 4.
- *Multiple Measures Can Be Combined into Several Overall Indices of Performance* – This concept is similar to the one put forth by Kaplan and Norton. If there are 64 vital measures, a way of reducing the number of measures is to create indices by assigning weights to measures in each group of metrics. A danger, Brown notes, is that a problem might not be noticed or trends may be hidden in the aggregate statistics.
- *Metrics Should Be Changed as Your Strategy and Situation Changes* – As problems are resolved and new problems arise, old metrics should be removed and new ones added. Often, customer needs change and new metrics are necessary.
- *Metrics Need to Have Targets or Goals Based on Research* – It is necessary to know what is good, how good is best, etc. for PM systems to contribute to the management of performance. Goals should be "challenging, worthwhile, and achievable." They should not be arbitrary. Ideally,

goals should be based on research on key competitors (*in our case, peer agencies*) both within the industry and outside of the industry.

- *Summary of a Strategic Measurement Model* – A good measurement model should start with Mission, Vision, and Values. The organization should then identify key success factors. A Balanced Scorecard that includes past, present, and future measures of performance should be created. The goals or targets for each measure should be established. Finally, the activities needed to achieve the goals should be implemented.

Brown proposes a six-step process for redesigning a measurement system:

1. *Prepare Guiding Documents* – Brown explains how to create a mission statement, a vision statement, and values statements.
2. *Conduct a Situation Analysis* – A situation analysis requires research into an agency's own strengths and weaknesses and those of its peers.
3. *Define Key Success Factors and Business Fundamentals* – Brown describes this step as critical. If key success factors are not identified here, the PM system will be doomed to failure.
4. *Identify Macro Performance Measures* – This involves identifying measurement categories, brainstorming measures in each category, and then narrowing them down to a vital few.
5. *Develop a Measurement Plan* – A measurement plan involves listing the selected measures, data collection methods, frequency, owner (the person responsible for the measure), and links to one or more key success factors.
6. *Design Data Collection Instruments and Procedures* – This step requires the most time. Does the data already exist? What data needs to be collected? How? These are questions that must be addressed in this step.

Finally, Brown describes visually appealing presentation methods—graphs that will succinctly convey performance results to decision makers.

Buckley, R.L., and P.E. Ward

"Service Standards and Operating Criteria in Nashville, Tennessee"
Transit Journal
American Public Transit Association, Summer 1978

Context: Informative paper

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Metropolitan Transit Authority, Nashville, TN

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? No

Performance Measures Identified:

- *Service delivery:* On-time performance, percent on-time arrivals, loading standards, percent seats occupied

Summary: This paper summarized the service standards adopted by the Metropolitan Transit Authority (MTA) of Nashville, Tennessee in 1976. These service standards were used by MTA to evaluate transit operations. Criteria used to evaluate system-wide performance are:

- Loading standards
- Policy headways
- On-time performance
- Bus stop spacing and location
- Bus schedule policies
- Route performance measures
- Standards for passenger amenities
- Definition of operating periods

The only criteria that were formally measured monthly include loading standards, on-time performance, and route performance. The other criteria were informally evaluated on a continual basis. The tables below show criteria that were used for loading standards and on-time performance.

Maximum Loading Standards

Operating Period	Type of Service	
	Express*	Arterial*
Peak 30 minutes	100%	125%
Peak hour	100	100
Base (non-peak)	75	75
Night	75	75
Saturday/Sunday	75	75

* Passengers as a percent of seats provided for a designated time period

Schedule Adherence

Time Period	Headway			
	< 10 min	10-30 min	30-60 min	Special Services
Peak Hour	75%	85%	95%	95%
Off-Peak	80	95	95	95
Saturday/Sunday	80	95	95	95

Note: On-time is defined as 0 minutes early to 5 minutes late.

Buneman, Kelvin

"Automated and Passenger-Based Transit Performance Measures"
Transportation Research Record 992
National Academy Press, Washington, DC, 1984

Context: Internal agency computer program used to develop count and delay statistics

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☒ Applications of technology

Transit Systems Evaluated: Bay Area Rapid Transit

Transit Modes Considered: Heavy rail, but could apply to any fixed-guideway system

Service Contracting Addressed? No

Performance Measures Identified:

- *Transit availability:* Impingement of failures on passenger-perceived service (UMTA 1978)
- *Service delivery:* Load factor (crowding), on-time performance, dependability (number of passenger trips on time times 100 and divided by total trips)
- *Speed & delay:* Expected delay (total passenger minutes of delay divided by total trips)

Summary: The author writes that, "Operational performance measures of a transit system are often best expressed in terms of the passenger." Potential measures include measures of productivity per passenger trip or per passenger mile, measures of crowding or seat capacity, and measures of on-time performance or schedule adherence. The focus of the paper is on measurement of crowding or seat capacity and measurement of on-time performance. The argument is made that that, from the passenger's perspective, there is a difference between an empty train being delayed and a full train being delayed.

The paper describes a computer program developed by BART to analyze (1) origin-destination and exit time data from automated fare gates and (2) records of train movements and door openings and closings from the central train control computer. From these data, passenger counts and load factors can be determined at critical points in the BART system and trainsets and schedules can be adjusted as necessary in the future to relieve crowding. Scheduled and actual arrivals are known, so train delay can be calculated. Passenger delay measures can also be calculated by matching passenger trips with timetables.

Data collection and the processing time and costs of the computer program are described.

California Department of Transportation (CalTrans)

1998 California Transportation Plan Transportation System Performance Measures Final Report
California DOT, Sacramento, CA, August, 1998

Context: The report describes elements of a good performance framework that will help California develop performance measures (PMs) and indicators for its transportation system. The purpose for PMs is "to develop indicators/measures to assess the performance of California's multi-modal transportation system to support informed transportation decisions by public officials, operators, service providers, and system users" and "to establish a coordinated and cooperative process for consistent performance measurement throughout California."

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified: See the summary.

Summary: The purpose of performance measures (PMs) is "to tell us where we are in terms of where we want to go" and to benchmark performance, identify problem areas, and assist in resource allocation. Also, measures can be used for:

- Monitoring and reporting on overall system performance
- Evaluating the performance impacts of programs
- Estimating the performance repercussions of large transportation projects

Effective measures/indicators should be easy to use and "understandable to decision makers, planners, and lay people alike. They should also rely on information or data that can be obtained at a reasonable cost and with reasonable effort." In addition, PMs should be measurable across all modes to the greatest extent possible. The report recommends using existing data sources and performance activities when possible. Regular reporting is also mentioned as being important to the success of a PM system (p. 3).

In general, the report states that PM systems should have:

- A clear direction of purpose or vision
- A simple set of metrics based on readily obtainable data
- Routine, readable reports

Also, the new PM framework for California should be:

- Customer driven
- Recognize impacts of transportation on non-transportation issues (and vice versa)
- Should be multimodal and multi-jurisdictional

The three phases required to establish the new framework are:

- Design phase – to gain support and reach consensus on new direction; describe how to measure the transportation system, how it would be used, and how it would be implemented
- Initial testing and design refinement phase – test methodologies in design phase
- Incremental deployment phase – to incrementally implement the refined design

Advice from key stakeholders in California were obtained via:

- A policy advisory committee – includes policy makers at every jurisdictional level
- A transportation assessment steering committee – technical representatives of stakeholder agencies
- Performance measurement conference – input from national and state thought leaders, academia, and stakeholder agencies were received
- Public forums – public input was obtained via statewide public forums

The advice from the stakeholders led to the following guidelines:

- Regional decision making will remain at discretion of regional agencies
- Some decisions will be made outside of the PM framework
- The state and regions will form partnerships to deploy the PM system, gather data, and enhance analysis tools.

California State University, Sacramento

The Impact of Public Transportation on Californians with Disabilities
California State University, Sacramento, Late 1999 or 2000
http://www.calsilc.org/transportation.pdf

Context: Profiling Californians with disabilities, assessing their transportation needs, and considering available transportation resources

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology
- ☒ Other: Discusses needs and issues related to persons with disabilities as it relates to public transportation

Transit Systems Evaluated: None

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified: None

Summary: This document was included because it provides a perspective oriented more towards the needs of persons with disabilities as it relates to paratransit service. Developing performance standards can consider these perspectives.

The document mentions that the ADA has not solved a lot of transportation problems which exist for persons with disabilities, and that in California there are many unmet needs for persons with disabilities. The ADA regulations characterize complementary paratransit as a safety net, but this study questions the assessment, noting that the ADA does not require transit agencies to provide any sort of spontaneous travel (same-day) for persons with disabilities.

The study notes that 30 percent of persons with disabilities see the level of transportation services as inadequate versus 10 percent of the general population. Transportation is viewed as a linchpin for persons with disabilities who aspire to individual autonomy. Another analysis shows the high cost of public transportation for persons with disabilities. While those in the general population who use public transportation spend 8 percent of their disposable income on public transportation, persons with disabilities spend 19 percent. It is also noted that the per capita income level of persons with disabilities is approximately 60 percent as high as that of the general population.

The study also notes that, while transit systems are often “accessible on paper,” the reality of poor attitudes and inadequate training undermine the reality of accessibility for persons with disabilities.

The conclusion is that transportation services are inadequate for persons with disabilities and, for service to become adequate, the level of service must improve well beyond the level required in the ADA. Additionally, for service levels to be more congruent with the ADA, compliance with the ADA must be in “spirit” as well as in letter. Attitudes and training should fully meet the requirements.

Cambridge Systematics, Inc.

"Multimodal Transportation: Development of a Performance-Based Transportation Planning Process"
NCHRP Report 446
Transportation Research Board, Washington DC, 2000

Context: The document was written to document the research and findings of NCHRP Research Project 8-32(2). This research was completed to support transportation planning efforts at the federal, state, and regional levels. The benefits to be gained by performance measurement, performance-based planning, and guidance to how this can be achieved is provided in this document.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Miami Valley Regional Transit Authority (Dayton, Ohio) was used as a case study.

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified:

- *Community-based:* Community-based service needs
- *Comfort & convenience:* Connectivity, time delay, passengers per platform hour, vehicle load factors
- *Service delivery:* Reliability, time and congestion, on-time performance
- *Service offered/utilization:* Accessibility
- *Economics/productivity:* Costs/benefits
- *Vehicular capacity:* Capacity, safety

Summary: The report is intended to provide transportation organizations, planning practitioners, and transportation decision makers with practical tools and guidance for considering system performance in the multimodal transportation planning and decision-making process. It is expected to support transportation investment decisions tailored to the specific conditions and performance needs of major transportation systems. Presented as a guidebook, it brings together lessons learned from different regions of the country and establishes a rationale for performance-based transportation planning and provides guidance for a wide range of applications having different scopes and levels of complexity. This guidebook provides a structured approach to monitoring, evaluating, and considering transportation system performance in various components of the planning process. It also includes a "Performance Measures Library" (Appendix B) that catalogs transportation measures currently being applied throughout the country. This guidebook should be especially valuable to planning practitioners in state departments of transportation (DOTs), metropolitan planning organizations (MPOs), and local transportation agencies, as well as other practitioners concerned with planning, programming, and implementing multimodal transportation projects. It should also be a useful educational resource on the concepts, tools, and procedures currently employed for establishing system performance as a basis for transportation planning and decision-making.

Comments: NCHRP Report 446 presents guidance for use by planning practitioners and other decision makers to design, manage, and carry out multimodal transportation planning that reflects performance objectives. Although this guidebook addresses many of the fundamental activities included in effective performance-based planning studies, the emphasis is not solely on the process. Rather, the emphasis is on how to organize and employ systematic, effective performance measures to support planning analyses and decisions. The principles and procedures are intended as guidance to practitioners, to be applied in a way that is tailored to the decisions being made. Although this guidebook focuses on the planning-level decisions, it emphasizes the importance of integrating planning and project development so that decision-making is, in effect, seamless and objective.

Cambridge Systematics

"Measuring and Valuing Transit Benefits and Disbenefits"
TCRP Report 20
National Academy Press, Washington, D.C., 1996

Context: This report was written to assist transportation professionals and policy makers in understanding how to measure and value transit benefits and disbenefits.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology
- ☒ Other: Evaluating impacts of transit

Transit Systems Evaluated: No specific transit systems

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified:

- *Community-based:* Air quality impacts, noise pollution, land use impacts, energy conservation, natural resource conservation, access to labor/business activity, real/perceived threat to personal security

Summary: This report is a departure from the majority of the other materials reviewed in that it does not discuss what most would consider to be typical performance measures. In fact, the report does not really discuss performance measures at all; rather, the report focuses on evaluating the impacts (both positive and negative) of transit systems. The authors present several different models capable of generating meaningful outputs that can then be used to determine the impact of a particular transportation mode. The report evaluates each of these models and concludes by providing recommendations on the best application for each model.

Comments: This report is full of interesting flowcharts illustrating the typical impacts associated with transit investment decisions.

Cambridge Systematics

National Transportation System Performance Measures, Final Report
U.S. Department of Transportation, Washington, D.C., April, 1996

Context: The NTS report supports the Office of the Secretary of Transportation's efforts to obtain information about performance measures (PMs) for the National Transportation System and assemble a representative set of performance measures.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified: See the summary.

Summary: The report emphasizes transportation's role in the national economy and society. The report states that national economy and society should be the primary focus, and operational characteristics of the transportation system should be a secondary focus of nationwide performance measurement. A hypothetical performance measurement framework is provided in Figure 3-1 in the report, with transportation policy, planning, and programs beneath the "primary national concerns" of the economy and social well-being.

The report suggests ideal measures for passenger and freight transportation. Many of these measures are related to or can be used for transit performance measurement. For passenger transportation, the indicators are divided into effectiveness and efficiency. Under effectiveness, accessibility and quality of service measures are suggested. Under efficiency, cost effectiveness and performance/utilization efficiency are mentioned.

The desired characteristics and uses of NTS Performance Measures are described as follows:

- *Assess Level of Performance* – They should be capable of reflecting how the nation's transportation system is functioning and performing to accomplish the variety of needs that the nation is imposing on it.
- *Customer-Oriented* – They should be capable of measuring transportation performance from the perspective of how it is serving the "customer," or user; that is, from the standpoint of the opportunity to make a "trip" and the quality of experience for an entire trip, not just the service level of a given mode, facility, or trip segment. Also, the availability of alternative modes to potential travelers (in case of emergencies or other unforeseen situations) is important and should be taken into account.
- *Outcome-Oriented* – They should address the outcomes of transportation activities, that is, the intended or unintended consequences of transportation policies, investments, and utilization on economic, environmental, and societal objectives. Outcomes are categorized into intended and unintended consequences. For the former, three general categories are mentioned: the economy, social well-being, and national security. For the latter, the categories include safety, environment, and natural resources.

- *Diagnostic* – The NTS measures would be "diagnostic" and identify major changes that occur and highlight elements that are not meeting the nation's needs. They would probably not tell decision makers what to do to fix the problem, but would trigger further, closer analysis. *(Once a problem has been identified, a "good" information system would enable transit agencies to locate the source of the problem and address it.)*
- *Encourage Dialogue* – NTS measures are intended to be outcome-oriented and, hence, would encourage dialogue among various groups affected by transportation.
- *Concise List of Measures* – The report mentions that a long list of measures may be generated initially. However, if all were included in a PM system, then the decision makers would be overwhelmed. "A more practical approach is to develop as short a list of robust measures as possible." The list should address the most critical policy or decision issues. "…The selection of the key measures represents an important policy decision in and of itself."
- *Divergent Perspectives* – The difference in perspectives among system users, operators and suppliers, providers and agencies, regulators and investors, and the general public must be considered, and the fact that different parties and market segments will have differing concerns and issues must be acknowledged. "In theory, these perspectives should not be different if there is really a unified view on the objectives for transportation. . . . To the extent that roles and responsibilities separate out in terms of market segments, modes, facilities, geography, and functions, PMs developed to assist a specific agency may not be consistent with the measures appropriate for evaluating the system as a whole from a customer/user perspective."
- *Data Issues* – How do data/analysis methods constrain the set of measures used? Although available data might constrain short-term ability to generate specific measures, in the long-term, the desired measures may assist in modifying or augmenting data collection and analysis methods. <u>Therefore, the initial set of desired measures should not be constrained by data availability or analysis issues.</u> Once the desired measures are identified, then questions should be asked about "how difficult it would be to obtain this new measure" and/or "identify existing measures which can be used as a proxy or surrogate until the desired measure is developed." *(Most sources mention that data issues are important and reliable data should be ensured to make performance measurement systems effective. However, the NTS report states that the data issues should be treated separately—ideal measures should be identified first, without considering data issues in the performance measures selection process.)*

Canadian Urban Transit Association

The Canadian Transit Handbook, 3rd Edition
Canadian Urban Transit Association, Toronto, Ontario, Canada, 1993

Context: This handbook is a manual of current practice. The earlier editions contain more background and theoretical detail.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Information was obtained from transit agencies throughout Canada.

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified:

- *Community-based:* Issues identified but no specific measures
- *Transit availability:* Accessibility, network connectivity, frequency of service, vehicle-kilometers of service provided, spacing of stops
- *Comfort & convenience:* Value of service, fare policy, information provided, design of stops, amenities, pedestrian orientation techniques, pedestrian safety, pedestrian security
- *Service delivery:* Unsatisfied telephone service calls (paratransit), unsatisfied trip requests (paratransit), double-booking of trips (paratransit), excessive vehicle travel times (paratransit), customer complaints (paratransit), maximum advance trip booking time (paratransit), percentage lost hours, vehicles early or late (on-time performance), accident frequency, load per vehicle at maximum load point, load per vehicle between stops
- *Service offered/utilization:* Number of active users (paratransit), trip cancellations (paratransit), customer no-shows (paratransit), revenue passengers per revenue hour or kilometer, percentage cash and ticket passengers, percentage pass passengers, percentage transfers, revenue passengers per capita, revenue passengers per square kilometer, revenue hours or kilometers per capita, revenue hours or kilometers per square kilometer, revenue passengers per vehicle, scheduled kilometers per minute of delay
- *Economics/productivity:* Cost per operating hour, revenue per pay hour, revenue per operating cost, passenger revenue per passenger, operating cost per passenger, net operating cost per capita
- *Speed & delay:* Access time, transfer time, average operating speed

Summary: Several chapters contain information relevant to the TCRP G-6 research. These chapters are described below.

Chapter 1, *Introduction*, briefly discusses the entities that provide transit service, including contractors.

Chapter 4, *System Financing*, discusses the equity of fare policies and suggests that riders of transit systems with distance- or zone-based fare structures may perceive service quality (i.e., value) differently depending on the length of their trip. This chapter also provides background on the elements of unit costs.

Chapter 5, *Marketing and Communications*, discusses market research data sources and data collection techniques, marketing strategies (such as segmentation of transit users), and how to communicate with transit users.

Chapter 6, *Service Design*, ties together Chapters 5, 7, 8, and 11. It provides background on classification and design of transit routes and networks.

Chapter 7, *Demand Estimation*, discusses travel demand models and the characteristics of transit demand, including land use factors, route structure, accessibility, network connectivity, frequency of service, fare policy, vehicle kilometers of service provided, and access and transfer time.

Chapter 8, *Customer Access*, focuses on the movement of pedestrians at stops and stations and in boarding and alighting. The chapter covers location, spacing, and design of stops; information and amenities; terminal and interchange facilities; fare collection and control systems; pedestrian orientation techniques; and pedestrian safety and security.

Chapter 11, *Service Monitoring*, is the chapter most relevant to TCRP G-6. The following tables summarize the performance data and performances measures (referred to as "indicators" in the Handbook) identified in this chapter. Chapter 11 also includes service performance indicators for paratransit and describes service monitoring techniques and systems.

Chapter 12, *Financial Control*, discusses the reporting of operational and financial information.

Chapter 13, *Transit Operations*, discusses how daily performance is recorded and monitored. Dispatchers, for example, record drivers' work hours, absenteeism, and vehicle kilometers. Measures such as scheduled kilometers per minute of delay (resulting from incidents such as vehicle breakdowns) may be used to indicate service reliability and staff response time.

Chapter 15, *Fleet and Maintenance Management*, discusses road call reports, which are "a primary source of performance data."

Performance Indicators Commonly Derived from Monitored Data

<table>
<tr><th colspan="3">Monitored Data</th></tr>
<tr><th>Operating Characteristics*</th><th>Revenue Characteristics</th><th>Ridership Characteristics</th></tr>
<tr><td>• Revenue hours
• Revenue kilometers
• Vehicle running times
• Percentage of accessible vehicles</td><td>• Passengers by fare category/media
• Transfer passengers
• Revenue passengers</td><td>• Vehicle loads
• Vehicle "ons and offs"
• Transferring between routes
• Access by persons with disabilities</td></tr>
<tr><th colspan="3">Derived Service Performance Indicators</th></tr>
<tr><th>Indicators for Planning</th><th>Indicators for Operations</th><th>Indicators for Administration</th></tr>
<tr><td>• Revenue passengers per revenue hour or kilometer (service utilization)
• Load per vehicle at maximum load point (vehicle utilization)
• Average operating speed
• Cost per operating hour</td><td>• Percentage lost hours (service reliability, dispatching efficiency)
• Vehicles early or late (service reliability, scheduling efficiency)
• Load per vehicle between stops (vehicle utilization)
• Accident frequency</td><td>• Percentage cash and ticket passengers
• Percentage pass passengers
• Percentage transfers</td></tr>
</table>

*Scheduled and actual

Service Performance Indicators Commonly Derived from Other Monitoring Programs*

<table>
<tr><th colspan="6">Base Data</th></tr>
<tr><th colspan="3">Service Data</th><th colspan="3">Support Data</th></tr>
<tr><td colspan="3">• Revenue passengers
• Revenue hours
• Revenue kilometers</td><td colspan="3">• Available vehicles
• Operator pay hours
• Passenger revenue
• Operating costs
• Service area population
• Area size (square kilometers)</td></tr>
<tr><th colspan="6">Indicators of Service Effectiveness</th></tr>
<tr><th colspan="3">Total Trips</th><th colspan="3">Service Level</th></tr>
<tr><td colspan="3">• Revenue passengers per capita
• Revenue passengers per square kilometer</td><td colspan="3">• Revenue hours or kilometers per capita
• Revenue hours or kilometers per square kilometer</td></tr>
<tr><th colspan="6">Indicators of Service Productivity</th></tr>
<tr><th colspan="2">Resource Level</th><th colspan="2">Revenue Level</th><th colspan="2">Cost Level</th></tr>
<tr><td colspan="2">• Revenue passengers per vehicle
• Revenue per pay hour</td><td colspan="2">• Revenue per operating cost
• Passenger revenue per passenger</td><td colspan="2">• Operating cost per passenger
• Net operating cost per capita</td></tr>
</table>

*Other monitoring programs include surveys of demographic information, information on resources, and information on costs.

Chapter 16, *Calculating Benefits*, describes community-based performance goals and provides guidelines on assessing transit's social, economic, energy, and environmental benefits. The goals include:

- Providing service to the transit-dependent and as an alternative when other transportation modes are out of service
- Increasing parking availability and to benefit merchants
- Supporting community programs
- Providing economic benefits through employment and making sites more attractive to developers
- Making residential locations more attractive with proximate transit access
- Acting as a "community watch" because drivers have two-way radios and regularly travel major streets
- Providing environmental and energy benefits
- Achieving a more "human scale" urban design

Comments: The chapter bibliographies may provide useful references.

"Value of service" reflects measures such as fare paid per distance traveled. This was taken indirectly from Chapter 4. Fare structure (e.g., cost of transfers) has implications for the perceived convenience of transit, too.

No target or sample values for the performance measures are provided.

Canadian Urban Transit Association

Canadian Transit Fact Book: 2000 Operating Data
Canadian Urban Transit Association, Toronto, Ontario, September 2001

Context: Summary of statistics on Canadian public transit systems

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Ninety-one systems

Transit Modes Considered: All

Service Contracting Addressed? Yes, but only in terms of operating expenses

Performance Measures Identified: (* = derived performance indicators)

- *Service offered/utilization:* Revenue vehicle kilometers, total vehicle kilometers, revenue vehicle hours, total vehicle hours, adult passenger trips, concession fare trips, regular service passenger kilometers, auxiliary service passenger trips, *regular service passengers per capita, *regular service passengers per revenue vehicle hour, *revenue vehicle hours per capita, *total vehicle kilometers per active vehicle
- *Economics/productivity:* *Revenue/cost ratio, *municipal operating contribution per capita, *net direct operating cost per regular service passenger, *regular service passenger revenue per regular service passenger, *total direct operating expense per regular service passenger, *total direct operating expense over total vehicle hours, operator paid hours, mechanic paid hours, total employee paid hours, *revenue vehicle hours per operator paid hour
- *Speed & delay:* Average speed, *revenue vehicle kilometers per revenue vehicle hour

Summary: This report provides a wide variety of 1998 and 1999 statistics on public transportation services provided by Canadian transit agencies that are members of the Canadian Urban Transit Association. These statistics include:

- Service area characteristics
- Passenger characteristics and data
- Operations data
- Operating expenses
- Operating funding sources
- Capital expenses
- Capital funding sources
- Vehicle characteristics
- Service hours/scheduling characteristics
- Fare structure
- Employee data
- Performance indicators (divided into Financial and Operating and listed above)

The report also contains a glossary (with equations for the performance indicators), a nationwide statistics summary, a provincial performance summary, a population group performance summary (based on urban area population), and graphs showing revenue/cost ratios, trips per capita, and cost per passenger by province and by population group.

Comments: The glossary and the performance indicator reports are particularly relevant to the TCRP G-6 project.

Canadian Urban Transit Association

"A Review of Canadian Transit Service Standards"
Canadian Urban Transit Association, Toronto, Ontario, March 2001

Context: Service standards survey results

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Forty-six Canadian systems surveyed

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified:

- *Transit availability:* Headway (peak, normal, and low demand), distance to service (by percentage of population), days and hours of service, bus stop spacing (average, minimum, and maximum)
- *Comfort & convenience:* Directness of routing (number of transfers required, maximum transfer rate, and travel time relative to car), collisions/safety
- *Service delivery:* Maximum occupancy (maximum in peak, maximum in off-peak, average in peak, average hour), on-time performance
- *Service offered/utilization:* Service utilization by route and by system (passengers per revenue vehicle hour under normal conditions and under exceptional conditions), annual rides per capita (market penetration)
- *Economics/productivity:* Revenue/cost (R/C) ratio
- *Speed & delay:* Travel time relative to car, transfer time, operating speed

Summary: The Canadian Urban Transit Association (CUTA) conducted this survey in response to member agencies' questions about the service standards in use by other agencies. The paper includes a discussion of the types of documents used in designing transit service (e.g., formal service standards and internal planning guidelines) and a definition of the service standards concept (i.e., "an objective rationale for allocating a transit system's limited resources in such as way as to strike a balance between the interests of different parties"). It also lists the most common variables that agencies address in their service standards. These include the performance measures listed above as well as:

- New service warrants (by distance from existing service, population/job density, maximum occupancy, and forecasted R/C ratio)
- Length of trial period for new or modified service
- Conditions for trial continuance
- Shelter policy
- Operator utilization standard (revenue vehicle hours divided by total vehicle hours)

The paper provides, for each variable identified in the survey, the reported range of values, the median reported value, and the most frequently reported value. The paper also discusses "atypical" standards. This discussion takes the form of a description of the variability in definitions of distance to service, bus stop spacing, shelter policy, service utilization, maximum occupancy, on-time performance, safety, R/C ratio, population/job density, and directness of routing.

The paper concludes by identifying four characteristics that "lead to a high quality standards document":

- *Precision* – Terminology must be clearly defined, and standards must be carefully worded.
- *Simplicity* – Standards should avoid obscure technical jargon. (For example, use "minimum revenue/cost ratio" instead of "efficiency target.")
- *Conciseness* – Short, concise standards are easier to understand and apply.
- *Realism* – Standards should reflect the service that the agency is capable of providing.

Comments: This paper provides many useful performance measure definitions and targets. Some are uncommon, such as (1) a travel time cap on one-way loops to minimize indirect routing and (2) using "weighted travel time" of affected customers to evaluate proposed service changes.

Canadian Urban Transit Association

Specialized Transit Services Fact Book: 2000 Operating Data
Canadian Urban Transit Association, Toronto, Ontario, September 2001

Context: Summary of statistics on Canadian transit systems that provide specialized transit services

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Sixty-one systems

Transit Modes Considered: Specialized urban and rural demand-response

Service Contracting Addressed? Yes, but only in terms of operating expenses

Performance Measures Identified: (* = derived performance indicator)

- *Service delivery:* Unaccommodated trip requests
- *Service offered/utilization:* *Registrants per capita, *passengers per capita, *passengers per registrant, *passengers per hour (dedicated service), *kilometers per passenger (dedicated service), vehicle kilometers (revenue and total), vehicle hours (revenue and total)
- *Economics/productivity:* *Revenue/cost ratio, *net operating cost per capita, *total expense per passenger, *total expense per eligible passenger, *transportation expense per passenger (dedicated service and non-dedicated service), *transportation expense per hour (dedicated service), no-shows, trips cancelled at door
- *Speed & delay:* Average speed (dedicated service)

Summary: This report provides a wide variety of 1999 and 2000 statistics on special transportation services provided by Canadian transit agencies that are members of the Canadian Urban Transit Association. These statistics include:

- Service area characteristics
- Fare structure
- Vehicle characteristics
- Employee data
- Operating data
- Ridership data
- Operating costs (total and net)
- Operating revenues
- Capital expenditures
- Capital funding
- Performance indicators (includes top wage rates - other measures listed above)
- Energy consumption

The report also contains a glossary, national and provincial summaries, population group summaries (based on urban area population), and graphs showing revenue/cost ratios, trips per capita, cost per passenger, and revenue per passenger by province and by population group.

Comments: The glossary and the performance indicator reports are particularly relevant to the TCRP G-6 project.

Carlquist, E.

"Incentive Contracts In Norwegian Local Public Transport: The Hordaland Model"
Proceedings of the THREDBO Conference
Institute of Transport Economics, Oslo, Norway, 2001

Context: Journal article on the incentive contracts implemented in Norway

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Three bus operators in Hordaland, Norway

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? Yes

Performance Measures Identified: See the summary.

Summary: The paper describes the performance-based incentive contracts implemented in Hordaland, Norway, for bus operators in the year 2000. It is concluded that, from focusing very strongly on cost reductions, the operator, who holds much of the responsibility for tactical level decisions (fares, network structure, and production), is clearly becoming more market-oriented. The year 2000 was a transitional phase, with only some elements of the performance contract being implemented. For example, a patronage-based incentive component initially suggested by the Institute of Transport Economics was taken out. The bonus (malus) system should be initiated in 2001, based on customer satisfaction (30%), reliability (10%), punctuality (10%) and passenger trips (50%).

In the contract suggested by the Institute of Transport Economics, the entire subsidy amount was to be performance-based, with specified rates for subsidies per route kilometer, per vehicle hour for peak hours and off-peak, and an additional amount per passenger in peak hours. These rates would vary among the operators, depending on the proportion of urban versus rural mileage, with a ceiling for the total amount. The authorities define a framework for the minimum quality of service, with regard to fares and accessibility. In the suggested contract, if customer satisfaction falls below 90 percent of the target level, based on a customer satisfaction survey, the authority can put the contract out for tender.

Using the assumption of only one performance item for simplicity (the Hordaland model has three), actual vehicle kilometers produced (*VKM*) and one rate (*RATE*), i.e., Norwegian Kroner per vehicle kilometer. The subsidy is subject to budgetary constraints and thus cannot exceed a predetermined level. A fixed deduction (*FD*) is defined in the base year (2000) and is subtracted to yield the subsidy (*S*), giving: $S_t = (RATE * VKM_t) - FD$, so the estimated subsidy for year 2000 will be $S_{2000} = (RATE * VKM_{2000}) - FD$.

As year 2000 is the starting point of the contract, the fixed deduction for the subsequent years (FD') depends on the actual mileage level in 2000: $FD' = (RATE * VKM_{2000}) - S_{2000.}$ Therefore, the subsidy for 2001 is a function of vehicle kilometers produced: $S_{2001} = (RATE * VKM_{2001}) - FD'$. It is commented that the key point is that not only ticket revenues but also the subsidy level depend on performance, i.e., vehicle kilometers in this simplified example. Therefore the profits (π) are co-determined by different performance-based factors, namely ticket revenues (*I*), subsidies (*S*), and costs (*C*). Ticket revenue is the product of fares (*P*) and demand (*X*), and demand is a function of vehicle kilometers (mileage production) and fares. $\pi = I + S - C$ where $C = f(VKM, \ldots)$ and $I = P*X$ and $X = g(VKM, P, \ldots)$. It is asserted that, given a "right" incentive (*RATE*), the operator will decide on a fare level (*P*) and production (*VKM*) at a level that maximizes profits and maximizes social welfare, given the budgetary constraints of the county council.

Carnell, Don S.

"Customer Defined Quality Standards: The Link between MARTA's Performance Excellence System, Strategic Planning, and Customer Satisfaction Research"
Presented at the UITP Organization of Transport and Quality of Service Conference
International Union of Public Transport, Florence, Italy, September 29-30, 1999

Context: Conference paper by MARTA administrators

Applicability to G-6 Project:
- ☒ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Metropolitan Atlanta Rapid Transit Authority (MARTA)

Transit Modes Considered: Urban fixed-route bus, heavy rail

Service Contracting Addressed? No

Performance Measures Identified:
- *Comfort & convenience:* Security, cleanliness, comfort, convenience
- *Service delivery:* Mechanical reliability, customer service
- *Service offered/utilization:* Customer Satisfaction Index, Loyalty Index

Summary: This paper first describes MARTA's "performance excellence" framework, which is characterized by:
- Understanding customers and business in terms of systems and processes
- Understanding and delivering products and services considered valuable to customers
- Continuously improving organizational performance and capabilities

The performance excellence framework applies to three areas of MARTA administration:

- *Strategic Planning* – Strategic Planning includes MARTA's strategic vision, mission, values, and initiatives. One of the initiatives is the Continuous Quality Improvement (CQI) initiative, which led to development of "a detailed mechanism to examine MARTA's processes for determining and enhancing customer satisfaction, building customer relationships, improving service offerings, and supporting customer and market related planning."

- *Customer Satisfaction Research* – MARTA conducts an annual Quality of Service Survey. This survey includes focus groups, development of a Customer Satisfaction Index and Loyalty Index, development of action plans, and communication of survey results.

- Customer Defined Quality Standards – "The premise behind MARTA's customer satisfaction research is based on the assumption that the primary driver of customer behavior is 'customer perceived value' in ... affordable fares, quality of service, and positive organizational image." MARTA measures these three perceptions with 62 service attributes categorized by:
    - Cleanliness
    - Convenience
    - Customer service
    - Employee performance
    - Mechanical reliability
    - Security

Each attribute is rated by Importance and by Performance.

Comments: The performance excellence system is based on the Georgia Oglethorpe Award Criteria. The paper does not explain what the Oglethorpe Criteria are, yet the Criteria are referenced throughout the paper. The 62 service attributes are not listed.

Carter, Dave, Timothy Lomax, and Ronald Jenson

"Performance Measures for Rural Transit Operators"
Research Report 2008-1F
Technical Report for Texas State Department of Highways and Public Transportation
Texas Transportation Institute, College Station, TX, 1990

Context: This report was written to provide small and rural transit operators with relevant information by which to evaluate their transit systems.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Since this report was written for the State Department of Highways and Public Transportation, it doesn't focus on any particular transit agency. Instead, the report provides guidance on how states can structure their transit performance measures. The report does analyze data from various rural transit properties throughout Texas.

Transit Modes Considered: Rural (general public and specialized)

Service Contracting Addressed? No

Performance Measures Identified:

- *Community-based:* Service area size, basic demographics, ridership by passenger type
- *Transit availability:* Total vehicle miles per capita
- *Service delivery:* Number of vehicles, total vehicle miles, vehicle utilization
- *Service offered/utilization:* Passengers per mile
- *Economics/productivity:* Total expenses, cost per trip, cost per mile, passenger trips per employee
- *Speed & delay:* Mechanical breakdown rate

Summary: The authors of this report emphasize that performance indicators should be relative in nature, as opposed to absolute figures. The performance measures are relative in the sense that a transit system's performance can be compared to previous years or the performance of its peers. The report also focuses on the use of performance measures for allocating funds to transit systems. The authors conclude that this practice motivates transit systems to improve performance if set up correctly. For instance, if only a small percentage of transportation funds are allocated based upon a system's performance, the system does not have much incentive to improve performance. Consequently, if performance measures are to be used for allocating funds, the authors recommend linking performance to a more significant funding amount than was practiced in Texas.

Comments: This report also includes a brief description of transit performance standards used in other states, including Florida, Georgia, Indiana, Iowa, Louisiana, Michigan, Minnesota, Montana, New York, North Carolina, Ohio, Oklahoma, Oregon, and Pennsylvania, in one of its appendices. The other appendices detail the peer group analysis and provide individual system profiles for the small/rural transit systems in Texas.

Carter-Goble Associates

Rural Public Transportation Evaluation Guide
U.S. Department of Transportation
Technology Sharing Program, Office of the Secretary of Transportation, Washington, D.C., 1982

Context: Carter-Goble's goal was to develop a manual that would allow rural transit systems to methodically monitor and evaluate system performance. This would provide a vehicle for rural transit managers to make informed decisions.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated:

Transit Modes Considered: Rural (general public and specialized)

Service Contracting Addressed? No

Performance Measures Identified:

- *Comfort & convenience:* Road calls
- *Service delivery:* Missed trips, accidents
- *Economics/productivity:* Passengers per hour, revenue, cost per hour, revenue, passengers
- *Speed & delay:* Dwell time

Summary: This guide provides the transit manager with a methodical and detailed guide for how to evaluate and correct performance. The indicators are explained thoroughly, and a five-step process is recommended for utilizing information in a manner that will enhance performance.

Comments: The approach is highly detailed but allows the manager to limit what measures to take to ensure that they are easily measured. The emphasis is on traditional measures: cost, revenue, on-time performance, and accidents.

The approach is effective for the scope that it provides but the quality indicators are limited to quality measures from the agency's standpoint and they are not necessarily what could be termed 'customer-focused.' The importance of measurability of the indicators is stressed—for example, while the study discusses less quantifiable measures such as company image, these types of measures are not quantified.

Center for Urban Transportation Research

Appendix A: Evaluation of Performance - 1991 Strategic Management Plan Objectives
Prepared for the Metro-Dade Transit Agency
Miami, FL, 1995

Context: This appendix reports the results of the Metro-Dade Transit Agency's efforts to implement their strategic mission plan of 1991.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: The Metro-Dade Transit Agency (MDTA)

Transit Modes Considered: Urban fixed-route bus, heavy rail, automated guideway transit

Service Contracting Addressed? No

Performance Measures Identified: See the summary.

Summary: MDTA's Strategic Mission Plan (SMP) of 1991 outlined seven "areas of excellence," or goals to strive for. This report, published four years after the SMP's implementation, discusses the results of the plan and the system's level of compliance in each area. The areas are marketing needs, human resources, funding, operating performance, financial/administrative performance, public/governmental relations, and capital construction. Each "excellence position" has a series of specific objectives, such as: "To increase per capita ridership system-wide by 3.5 percent for bus and 4 percent for rail by October 1991." Altogether, there are 83 such objectives.

Within the Operating Performance position, there are 10 such objectives. These are:

- "Improve on-time performance by 20 percent for bus, 5 percent for rail, and 30 percent for STS."
- "Improve mileage between lost service bus road calls from 10,000 to 15,000 miles."
- "Improve ratio of scheduled vehicle revenue hours actually worked to schedule vehicle revenue hours from 97 to 98 percent for rail."
- "Achieve 100 percent departure for bus, rail, and mover."
- "Achieve and sustain a maximum of one-day turnaround for minor defects."
- "Improve aggregate system safety by 10 percent by October 1991."
- "Increase number of telephone calls answered per transit information clerk-person-hour by 10 percent."
- "Achieve and maintain a maximum hold time of two minutes for incoming calls."
- "Reduce the number of customer complaints by 10 percent."
- "Increase boardings per vehicle revenue hour by 5 percent for rail and 6 percent for mover."

Comments: MDTA's performance varied with regards to each of these measures. What is actually most valuable for the purpose of this review, however, is the real-world demonstration of how performance standards can be set relative to system goals, rather than how actual indicators can be measured to evaluate how well the system is meeting its standards.

Center for Urban Transportation Research

Performance Evaluation of Florida's Transit Systems: Part 1, Fixed-route Trend Analysis 1984 - 1996
University of South Florida, March 1998

Context: This is Part 1 of a four-part report produced for the Florida DOT evaluating Florida's transit systems as required by Florida law.

Applicability to G-6 Project:
- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: This report examines all 19 fixed-route transit agencies in Florida.

Transit Modes Considered: Urban fixed-route bus, heavy rail, commuter rail, automated guideway transit

Service Contracting Addressed? Yes

Performance Measures Identified:
- *Service delivery:* Vehicle miles, revenue miles, vehicle hours, revenue hours, route miles, vehicles available for maximum service, vehicles operated in maximum service, spare ratio, total gallons consumed, total energy consumed (kilowatt-hours), vehicle miles per peak vehicle, vehicle hours per peak vehicle, vehicle miles per gallon, vehicle miles per kilowatt-hour
- *Service offered/utilization:* Vehicle miles per capita, passenger trips per capita, passenger trips per revenue mile, passenger trips per revenue hour, average speed, average age of fleet, number of incidents, revenue service interruptions, revenue miles between incidents, revenue miles between interruptions, revenue miles per route mile, service area, service area population, passenger trips, passenger miles
- *Economics/productivity:* Operating expense per capita, operating expense per peak vehicle, operating expense per passenger trip, operating expense per passenger mile, operating expense per revenue mile, operating expense per revenue hour, maintenance expense per revenue mile, maintenance expense per operating expense, total operating expense, total maintenance expense, total capital expense, total local revenue, operating revenue, passenger fare revenue, total employees, transportation operating employees, maintenance employees, administrative employees, farebox recovery, local revenue per operating expense, operating revenue per operating expense, revenue miles per vehicle mile, revenue miles per total vehicles, revenue hours per total vehicles, revenue hours per employee, passenger trips per employee, average fare

Summary: This paper evaluates all of Florida's fixed-route transit systems using three categories of performance measures: performance indicators, effectiveness measures, and efficiency measures. These categories do not fit evenly in the classification scheme of this review structure, and therefore were divided into the above categories as best as could be determined. The report contains little discussion of the reason for choosing these measures, instead focusing more on reporting the results for each system in Florida.

The majority of Florida's transit systems are experiencing increasing trends in most performance indicators. One notable exception is that only six of the 19 agencies show an increase in the number of *vehicles available for maximum service*. Twelve systems indicate a positive trend in the number of *vehicles per capita*, while eight of the 19 systems experienced a positive increase in the *ratio of passenger* *trips to revenue miles*. These positive improvements come at an increased cost, however, with the majority of Florida's systems experiencing an increase in all four cost ratios used: operating expense per capita, operating expense per passenger trip, operating expense per revenue mile, and maintenance expense per revenue mile. Yet, the higher costs seem to be translating into higher levels of service, as both vehicle utilization (*vehicle miles per peak vehicle*) and employee productivity (*revenue hours per employee*) increased overall.

The remainder of the report consists of individual reports for each fixed-route transit system in Florida and offers little else of interest to the G-6 project.

Comments: This is an excellent hard numbers paper and provides a very strong statewide example of how performance measures are being used to both measure and improve transit service.

Center for Urban Transportation Research

Performance Evaluation of Florida's Transit Systems: Performance Reporting Investigation
University of Southern Florida, Tampa, FL, October 1996

Context: Florida DOT requires that all transit systems under its jurisdiction report productivity and performance measures for their operation. This paper compares these reports to the systems' Federally mandated Section 15 reports and evaluates their consistency and results.

Applicability to G-6 Project:

- [x] Performance-measurement program description(s)
- [ ] Characteristics of effective performance measures or measurement systems
- [x] Performance measure examples
- [ ] Market research
- [x] Performance reporting
- [ ] Applications of technology

Transit Systems Evaluated: Nineteen transit systems were evaluated for this study, all within the state of Florida.

Transit Modes Considered: Urban fixed-route bus, heavy rail, commuter rail, automated guideway transit

Service Contracting Addressed? Yes

Performance Measures Identified:

- *Service delivery:* Vehicle miles, revenue miles, vehicle hours, revenue hours, route miles, vehicles available for maximum service, vehicles operated in maximum service, spare ratio, total gallons consumed, total energy consumed (kilowatt-hours), vehicle miles per peak vehicle, vehicle hours per peak vehicle, vehicle miles per gallon, vehicle miles per kilowatt-hour

- *Service offered/utilization:* Vehicle miles per capita, passenger trips per capita, passenger trips per revenue mile, passenger trips per revenue hour, average speed, average age of fleet, number of incidents, revenue service interruptions, revenue miles between incidents, revenue miles between interruptions, revenue miles per route mile, service area, service area population, passenger trips, passenger miles

- *Economics/productivity:* Operating expense per capita, operating expense per peak vehicle, operating expense per passenger trip, operating expense per passenger mile, operating expense per revenue mile, operating expense per revenue hour, maintenance expense per revenue mile, maintenance expense per operating expense, total operating expense, total maintenance expense, total capital expense, total local revenue, operating revenue, passenger fare revenue, total employees, transportation operating employees, maintenance employees, administrative employees, farebox recovery, local revenue per operating expense, operating revenue per operating expense, revenue miles per vehicle mile, revenue miles per total vehicles, revenue hours per total vehicles, revenue hours per employee, passenger trips per employee, average fare

Summary: This paper compares the results of the State-mandated reporting requirements with the Federally mandated Section 15 (now National Transit Database) performance reporting requirements for public transit agencies in Florida. It found that 18 out of 19 agencies complied with both State and Federal legislation in a timely and public manner. The report also found that there were consistent discrepancies in reported data, particularly around different measures such as the age of the fleet, revenue miles per total vehicle, passenger trips per capita, revenue hours per employee, and passenger trips per employee. The report believes that this was caused by different reporting or measurement errors, such as reporting the incorrect indicator, rounding the differences, using 1994 instead of 1995 as a base year for calculating average fleet age, using different service area population measurements, or different interpretations of the number of peak hour vehicles relative to the total active fleet. Despite these inconsistencies, the report found that Florida transit agencies were in general reporting accurate and detailed information at both the local and national levels. The authors conclude with a call for further standardization of reporting measures and point out that performance measurement and reporting programs are playing a valuable role in the operation of Florida's transit systems.

Center for Urban Transportation Research

Transit Customer Satisfaction Index for Florida Transit Properties
Technical Memorandum #3: Results and Analysis of Florida Transit Properties
Center for Urban Transportation Research, University of South Florida, Tampa, FL, October 1997

Context: Third technical memorandum in CUTR's Transit Customer Satisfaction Index (CSI) project for FDOT

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology
- ☒ Other: Customer satisfaction model development

Transit Systems Evaluated: Broward County Transit (Pompano Beach/Ft. Lauderdale, FL), Pinellas Suncoast Transit Authority (Clearwater/St. Petersburg, FL), Jacksonville Transportation Authority, LYNX (Orlando, FL), TalTran (Tallahassee, FL), Lee County Transit (Ft. Myers, FL)

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? No

Performance Measures Identified:

- *Transit availability:* Hours of service by day and weekend, frequency of service, on-time performance, availability of route information, bus stop locations
- *Comfort & convenience:* Convenience of routes, ease of transferring and transferring policy, cost of fare and transfers, vehicle cleanliness, comfort of ride, employee courtesy, perception of safety at bus stop, overall satisfaction
- *Speed & delay:* Travel time

Summary: This paper describes the development, application, and evaluation of a Transit CSI. These tasks include a survey of six Florida transit agencies' riders, data analysis, and customer satisfaction modeling. The overall objectives of the Transit CSI project consisted of:

- Providing a systematic evaluation of transit customer satisfaction
- Providing insight into the factors that influence transit customer satisfaction
- Comparing customer satisfaction data of surveyed transit systems with data from other systems in Florida and the U.S.
- Recommending methods and practices for increasing transit customer satisfaction

The on-board surveys asked riders to rate the following factors:

- Hours of service by day and weekend
- Frequency of service
- Convenience of routes
- On-time performance
- Travel time
- Ease of transferring and transfer policy
- Cost of fare and transfers
- Availability of route information
- Vehicle cleanliness
- Comfort of ride

- Employee courtesy
- Perception of safety on bus and at stop
- Bus stop locations
- Overall satisfaction

From the surveys, the authors constructed an "importance-performance matrix" for each surveyed system. These matrices relate average rider perception of a given service element's performance (such as the usefulness of printed schedules) to the perceived importance of that element and provide guidance to the agency on prioritizing service improvements.

Comments: The authors write that, unlike most of the related studies that they reviewed, their study investigates customer satisfaction associated with the deboarding area.

Most of the paper is about survey design and analysis, but results are detailed for each surveyed system. The results were used in the TCRP A-15 project to help identify the service measures used in the TCQSM. The authors make an interesting point about bias in the survey design, namely that, in on-board surveys, higher-frequency riders are more likely to be surveyed than lower-frequency riders. Similar conclusions have been drawn by researchers in Kentucky and Alberta.

Center of Transportation Excellence and Development

Efficiencies in Paratransit Scheduling and Dispatching
University of Wisconsin, Milwaukee, WI, August 2000

Context: Course textbook, providing an overview of ADA paratransit and the needed policies, procedures, and practices for effective scheduling and dispatch techniques

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: Urban demand-responsive (general public and specialized)

Service Contracting Addressed? No

Performance Measures Identified:

- *Comfort & convenience:* On-time performance
- *Service delivery:* Missed trips, wait time
- *Service offered/utilization:* Ridership, peak hour vehicles
- *Economics/productivity*: Passengers per hour, passengers per mile, cost per hour, cost per mile, farebox return ratio
- *Speed & delay:* Travel time, dwell time, system speed

Summary: This is the course textbook for a two-day course in paratransit scheduling and dispatch efficiency. Performance standards are discussed in the early part of the course as part of an exercise in understanding the environment in which paratransit currently operates.

The course materials do not reflect the verbal portion of the instruction. Performance standards and measures are presented more as possible options to consider and are not explained in great detail. This is understandable, since the focus of this course is upon scheduling and dispatch operations and how it can be made effective and efficient.

Cervero, Robert

Paratransit in America: Redefining Mass Transportation
Praeger Publishers, Westport, Connecticut, 1997

Context: The author asserts that allowing competitive market forces to drive a wide range of paratransit services will provide better, more efficient paratransit services that can serve as a component to resolving the United States' travel problems.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Various

Transit Modes Considered: Urban fixed-route bus, urban and rural demand-response (general public and specialized)

Service Contracting Addressed? Yes

Performance Measures Identified:

- *Service offered/utilization:* Ridership
- *Economics/productivity:* Cost per hour, passenger, ridership
- *Speed & delay:* Travel time, speed

Summary: Cervero's book is an examination of paratransit in the United States and around the world. It is considerably broader than looking at public paratransit or ADA. It examines airport shuttles, taxi service, jitneys, and other forms of transportation.

His thesis is that paratransit exists in an environment where it is over-regulated, mis-priced, and allows for the protection of unnatural monopolies. Cervero's approach is to utilize free market forces to enhance the quality and effectiveness of paratransit. He distinguishes "commercialization" from the privatization effort that began in the mid-1980s. Under privatization, a single company provides transit services, which, according to Cervero, replaces a public monopoly with a private one, resulting in no change in productivity or quality. Cervero argues that paratransit is a more effective transit solution for emerging land use and travel patterns of the last thirty years.

Cervero argues that quality is a problem because paratransit monopolies are inefficient and over-regulated. Improving performance and enhancing quality is tied to removing these barriers. Cervero describes paratransit experiences where regulations are less intrusive as being more effective in meeting service demands.

Comments: While the transit industry is not fully embracing Cervero's arguments, some of the competitive notions are finding their way into the organizational structure of ADA paratransit. Contracting to multiple providers and allowing providers to compete over passengers is becoming more popular, and introduces market forces and consumer choice as mechanisms to enhance quality.

Chicago Transit Authority

Chicago Transit Authority Service Standards
Transit Operations Division, Chicago Transit Authority, Chicago, IL, July 2001
http://www.transitchicago.com/news/newspostdescs/129737.pdf

Context: Standards document

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology
- ☒ Other: Standards

Transit Systems Evaluated: Chicago Transit Authority (CTA)

Transit Modes Considered: Urban fixed-route bus, urban demand-response (specialized), heavy rail, flexible routes (under study)

Service Contracting Addressed? No

Performance Measures Identified:

- *Transit availability:* Customer walk distance, hours of operation, days of operation, frequency
- *Service delivery:* Passengers per bus, passengers per rail car
- *Economics/productivity:* Boarding passengers per hour

Summary: The purpose of the CTA *Service Standards* document is to "provide a framework for a consistent and fair evaluation of both existing and proposed services." The five key influences on service design are:

- *Service Coverage* – The Service Coverage policy determines the average customer walk distance to get to a bus stop or rail station at certain times of day. The maximum allowable walk distance is one-half mile during most time periods.

- *Span of Service* – The Span of Service policy covers the hours and days that routes operate. For "key" routes, services are generally offered at least 16 hours a day, seven days a week. Extensions are considered when the hour at the beginning or end of the current service period is more productive than the system average.

- *Frequency of Service* – The Service Frequency policy determines how long passengers wait for service. The maximum headway between buses and trains is 30 minutes.

- *Passenger Flow* – The Passenger Flow policy determines how crowded vehicles are when they arrive at the busiest location on their routes. An average of 60 passengers per bus is scheduled on the most crowded routes at the busiest locations. An average of 90 passengers per car is scheduled for rail.

- *Minimum Productivity* – The minimum productivity for bus service that runs at 30-minute headways is 30 boarding passengers per hour. Productivity is reported by route (for buses) and by line and station (for rail).

More details on these five policies can be found in the following tables.

Bus Service Coverage Guidelines

Time Period	Distance between Routes	Typical Walk Distances
Weekday Peak		
High Density	1/2 mile	1/4 mile
Low Density	1 mile	1/2 mile
Weekday Midday/Evening	1 mile	1/2 mile
Saturday and Sunday/Holidays	1 mile	1/2 mile
Owl	2 miles	1 mile

Relationship between Passenger Flow and Service Frequency

Mode	Passenger Flow per Half Hour in One Direction	Interval between Vehicles	Average Number of Passengers per Bus/Car	Train Length
Bus	300 to 360	5 minutes	50 to 60	--
Rail	3,840 to 4,680	4.5 minutes	75 to 90	8
Rail	3,510 to 4,050	4 minutes	75 to 90	6

Peak Period Bus Service Levels for 60-passenger Maximum Load

Passenger Flow per Half Hour	Service Interval in Minutes	Passengers on Bus (Average for Period)
≤30	30	<30
30-60	20	20-40
60-90	15	30-45
90-125	12	35-50
125-165	10	40-55
165-240	7.5	40-60
240-300	6	45-60
300-360	5	50-60
>360	<5	60

*The document contains service level tables for articulated buses, rail, and off-peak service.

The following facilities and customer amenities measures are included in CTA's service standards:

- *Bus stop spacing* – Bus stops are typically located at major intersections and/or traffic generators and typically spaced a block apart.
- *Bus stop amenities* – These include shelters and benches.
- *Rail station spacing* – Station spacing is based on demand and the purpose of the rail segment (e.g., speed vs. collection and distribution).
- *Distribution of revenue equipment* – Factors affecting the allocation of equipment throughout the fleet accessibility, air conditioning, average age of vehicle, and number of vehicle types at each garage.

The document includes the process for changing service. The evaluation criteria for service analyses include:

- *Primary Criteria for Service Improvement* – net cost per new passenger, available budget, rationale for the change, existing and projected ridership, number of new passengers, existing and projected operating costs, existing and projected fare revenue, implications to service coverage

- *Primary Criteria for Service Reduction* – net savings per passenger lost, rationale for the change, existing and projected ridership, existing operating costs, existing fare revenue, implications to service coverage
- *Secondary Criteria for Service Improvement* – market change (past, present, and projected), change in travel time for existing passengers, key characteristics and demographics of the market, contribution to the achievement of policy objectives, other factors as appropriate
- *Secondary Criteria for Service Reduction* – market change (past, present, and projected), change in travel time for existing passengers, key characteristics and demographics of the market, contribution to the achievement of policy objectives, impact on accessibility, other factors as appropriate

Service monitoring includes comparing ridership to service frequency, running time checks, and analysis of automated fare collection (AFC) data. Regular customer surveys are conducted, as well as specific route- or market-based surveys.

The appendices to the standards include Bus and Rail Design Guidelines, Calculating Service Costs, Service Proposal Evaluation Worksheets, and Niche Market Services.

Comments: The service change evaluation criteria assign passenger-oriented and community measures less priority than economic measures. This seems to be intentional, as the primary evaluation criteria are "used to determine the economic viability and sustainability of service changes," and the secondary criteria are "included to provide a complete picture of the impacts of the change."

Christopher, Mary Kay, Darwin Stuart, and Peter J. Foote

"Structuring and Assessing Transit Management Response to Customer Satisfaction Surveys"
Transportation Research Record 1669
National Academy Press, Washington, DC, 1999

Context: The paper describes the relationship between transit management efforts to improve customer satisfaction and the results of two customer satisfaction tracking surveys conducted in 1995 and 1997, in terms of both the individual service attributes addressed (42-45 individual attributes), as well as nine different, broader performance dimensions developed to group these attributes.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☒ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Chicago Transit Authority (CTA)

Transit Modes Considered: Urban fixed-route bus, heavy rail

Service Contracting Addressed? No

Performance Measures Identified: See the summary.

Summary: The paper examines a series of management Action Programs, some derived directly from the 1995 customer satisfaction survey, in terms of possible explanation of improvements in (or having no apparent effect upon) related customer satisfaction measures. It also provides evidence that both the measurement of transit customer satisfaction, as well as the contribution of management actions to improve it, are "moving targets"—in terms of the complexities of survey administration, supporting statistical analysis, and poorly understood "background socio-economic factors" that affect all of these. In addition, a number of major ongoing agency initiatives, with multiple facets covering a number of service dimensions, and overlapping more specific efforts, are described.

In the two years following the 1995 customer survey, CTA management developed a number of service quality and related improvement initiatives. These were of two types: (1) those that emerged from ongoing work of the interdepartmental team that monitored the 1995 survey, and (2) those that were developed through other efforts. Based on the 1995 survey, the top customer-defined improvement priorities were: on-time performance, reducing wait time when transferring, the frequency of service (time between buses or trains), schedule information, and maintaining the cost of a one-way ride. Additional factors that significantly influenced the selection of action areas were the time and effort necessary to inaugurate activities, the availability of staff to undertake the effort, and the operating flexibility to begin work. Five action plans were developed, discussed, and inaugurated. Most changed shape and focus, and evolved through the 15 months of implementation. The five action plans were:

- timetable (schedule) enhancement and increased availability
- bus supervisor skills enhancement training, including feedback from the 1995 customer survey
- improvement of rail on-board announcements
- rail system panhandler/vendor deterrence program
- prototype "super service" enhancement on a specific bus route

In addition, three other major ongoing initiative addressed concerns raised by customers. These were automated fare control implementation, a station improvement program, and administrative cost cutting. Former "ticket agents" were retrained as customer assistants, available to answer questions about the new farecard system. The general CTA belt-tightening received major press coverage, and is also regarded as a factor in CTA's overall image.

CTA experienced an overall increased in customer satisfaction of 9% from 1995 to re-measurement in 1997. However, the relative position of most of the customer-defined improvement priorities remained the same, indicating the marginal effect of the five specifically targeted action plans.

The result may suggest that the improvement levels measured by such administrative and operational data as number of accidents, number of delays, and increased supervisor hours, did not change to a sufficient level to be "noticed" by the typical rider. It may also mean that insufficient time had passed between the two surveys in order for riders to appreciate any service gains.

Comments: The major ongoing agency initiatives appear to have had a more measurable impact on customer satisfaction improvement than smaller-scale, targeted efforts. It may take major sustained service improvements before some types of service features will be perceived by customers as having been significantly improved.

Citizens Planning and Housing Association

"State of the Buses 2000"
Citizens Planning and Housing Association, Baltimore, MD, 2000

Context: Citizens' group assessment of bus service quality; funded by the City of Baltimore, the Maryland Mass Transit Administration (MTA), and others

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Baltimore, Maryland

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? No

Performance Measures Identified:

- *Community-based:* Wheelchair accessibility
- *Transit availability:* Information at stops
- *Comfort & convenience:* Seating availability, bus cleanliness, seating and shelter at stops, air conditioning, condition of windows, condition of seats, maps and schedules on board, route markings on buses, driver announcements
- *Service delivery:* On-time performance, frequency of accidents

Summary: This report summarizes the results of the 2000 Citizens Planning and Housing Association (CPHA) survey of passenger-perceived bus service quality in Baltimore. The report concludes that, overall, "there has been only marginal progress in meeting the highest standards of bus service quality" but "bus operations are heading in the right direction."

Thirteen service quality indicators were selected from a review of relevant literature and consultation with MTA. These indicators are:

- Service Reliability Indicators
  - On-time performance – Buses are late if they leave more than one minute before or four minutes after the scheduled departure time.
  - Seating availability – Surprisingly, 11:00 a.m. to 3:00 p.m. was found to be one of the time periods in which buses were "most likely to be overcrowded." A distinction between "comfortable" and "uncomfortable" standing is made.
  - Wheelchair accessibility – Lifts may not function due to operator error, inability to pull to the curb, or broken equipment.

- Passenger Environment Indicators
  - Bus cleanliness – Bus cleanliness is the responsibility of the agency and the passengers.
  - Bus stop cleanliness – Bus stop cleanliness is the responsibility of property owners and jurisdictions, with oversight from MTA.
  - Seating and shelter at bus stops – No surveyed route received a passing score.
  - Air conditioning
  - Condition of windows – Almost 10 percent of buses had two or more damaged windows.
  - Condition of seats

- Information Availability
  - Information at bus stops
  - Availability of schedules on board
  - Route markings on buses
  - Announcements of transfer points and intersections – “Only on 11 percent of all trips were announcements [made]. This is a clear violation of the Americans with Disabilities Act....”

Frequency of accidents per route was also included in the report.

The indicators were scored with letter grades based on the number of points received out of the total possible points. The letter grades were adjusted in some cases by pluses or minuses where CPHA staff had additional information. The scoring thresholds were:

- “A” = 90 percent or better = “Excellent”
- “B” = 80 to 89 percent = “Good”
- “C” = 70 to 79 percent = “Fair”
- “D” = 60 to 69 percent = “Not Acceptable”
- “F” = below 60 percent = “Failing”

Comments: It is interesting to compare the on-time performance results with typical agency standards.

Codd, N., and C.M. Walton

Performance Measures And A Framework For Decision-Making Under The National Transportation System

Center for Transportation Research, University of Texas; Southwest Region University Transportation Center, Texas Transportation Institute, Texas A&M University, 1995

Context: This document addresses ISTEA legislation that calls for transportation planning to be based on efficiency and the system's performance in terms of moving goods and passengers.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: Passenger movement addressed in general

Service Contracting Addressed? No

Performance Measures Identified: Numerous; some pertinent ones are identified below.

- *Service offered/utilization:* Mobility index
- *Economics/productivity:* Jobs supported/PMT; Impact on gross metropolitan or state product/PMT
- *Vehicular capacity:* Passenger miles traveled; passenger usage/passenger capacity; passengers transferred per hour; passenger usage/passenger transfer capacity
- *Speed & delay:* Safety (accident, injury, fatality and crime rates); in-vehicle travel time, in-vehicle delay time, intermodal transit time, waiting time

Summary: The authors examine ISTEA legislation and the change in focus from modal transportation planning to intermodal planning. ISTEA requires that performance of all modes and facilities is considered and that ISTEA funding can be used for expenditure on projects in any number of different modes. Decision making under ISTEA is explored and major funding components of ISTEA described. The authors then provide a description of the National Transportation System (NTS), its mission and its policy goals. The NTS is to be a mechanism for producing the following:

- Transportation performance measurement system
- National and regional transportation analytical capability, and
- State of the Transportation System Report.

Four separate objectives of the NTS are also identified. The primary goals of the NTS are to monitor the nation's transportation network, in all modes, for freight as well as passengers, and to support national transportation planning and policy that maximize the efficiency and effectiveness of the network.

In order to do this, the NTS must evaluate the transportation network based on its performance, regardless of mode. Therefore, the NTS must have as its basis a set of measures applicable to different modes, which reflects the varied goals of ISTEA, in the areas of mobility, environmental, social, and economic performance. In order for performance measures to be based mostly on available data, the authors identify the data requirements and several data sources while precluding any major, expensive data collection efforts. Potential problems with NTS data are also identified. The authors then propose several performance measures for the NTS. These were refined after feedback from a variety of transportation professionals. The performance measures are to be intermodal in nature so that they can allow comparison of trips across modes. A general decision-making framework for utilizing the selected performance measures is then presented and discussed.

Comments: Data dependence and the possibility that some of the required data may not be readily available is a potential weakness of the performance measures suggested. The paper raises several issues relating to cost and objectives of the NTS. The authors do state that their proposal is designed “to offer options and promote debate on the objectives and the methodology for achieving these objectives.”

Community Transportation Association of America

Maximizing Paratransit Productivity
Training handbook developed in partnership with Trapeze Software Group
Washington, D.C., 1999

Context: Provides explanations of available options and techniques that will allow communities to build effective demand-responsive service

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology
- ☒ Other: Best practices

Systems Evaluated:

Transit Modes Considered: Urban and rural demand-response (general public and specialized)

Service Contracting Addressed? Yes

Performance Measures Identified:

- *Transit availability:* Reservation phone hold time, service denials
- *Comfort & convenience:* Preventative maintenance
- *Service delivery:* Missed trips, accidents, travel time, on time performance
- *Service offered/utilization:* Ridership (including companions and personal care attendants), complaints, and commendations
- *Economics/productivity:* Cost per passenger, cost per service hour, cost per service mile, administrative costs, capital costs, contractor performance incentives/penalties
- *Speed & delay:* Average dwell time, load time, travel time

Summary: The topic of the book is maximizing paratransit productivity, but the guidebook actually is considerably broader in scope. Its broader scope is both necessary and valuable particularly in assisting the transit manager with grasping the often-conflicting goals of managing paratransit productivity.

Maximizing productivity must be viewed in a larger context and that includes the unique regulatory and financial realities of ADA complementary paratransit. Quality and service efficiency are sometimes conflicting goals but the authors make some key points regarding this conflict:

- There is no single solution for maximizing paratransit effectiveness. Effectiveness requires quality management using a variety of tools and techniques.
- Solutions to maximizing ADA productivity are dependent upon developing solutions reflective of the unique geographic, political, and other characteristics of each agency.
- An appreciation of the needs of the ADA customer and the impact various ADA operating policies and procedures have upon the customer is necessary.

The authors point out that in paratransit, many policies and procedures designed to maximize program effectiveness are looked upon by paratransit riders as rules and guidelines that are anathemas to their mobility needs. For example, a strict ADA eligibility program of in-person interviews and functional assessment can maximize paratransit effectiveness by ensuring only those that truly need the service qualify. However, passengers may view the program as onerous and even discriminatory towards persons with disabilities. The authors address those dilemmas by emphasizing the need for an honest and forthright dialogue with ADA passengers and the disabled community so that they can be involved in the determination of what constitutes effective performance.

The authors classify valid performance standards by:

- *Service delivery* – On time performance, denials, road calls, missed trips, no-shows
- *Customer service* – Phone hold time, complaints/commendations
- *Quality assurance* – Preventative maintenance, cleanliness, body damage, safety (miles between accidents), driver training, passenger relations
- *Cost effectiveness* – Passengers per vehicle hour, cost per trip, cost per mile, average fare, subsidy per trip
- *ADA* – Revenue miles/total vehicle miles, ridership counting, revenue hours/total vehicle hours

Performance monitoring for private contractors is discussed in detail along with the desirability for performance incentives and penalties for the contractor over areas they can control.

Comments: *Maximizing Paratransit Productivity* takes a practical and balanced approach to effectiveness. It recognizes that simply being efficient will not work—that customer and service quality considerations must be considered.

Cunningham, Lawrence F., Clifford Young, and Moonkyu Lee

"Developing Customer-Based Measures of Overall Transportation Service Quality in Colorado: Quantitative and Qualitative Approaches"
Journal of Public Transportation, Volume 1, No. 4, pp. 1-19
Center for Urban Transportation Research, Tampa, FL, 1997

Context: Measurement of perceived service quality in Colorado's transportation system

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology
- ☒ Other: Survey technique

Transit Systems Evaluated: None specifically

Transit Modes Considered: All, in a very general way

Service Contracting Addressed? No

Performance Measures Identified:

Summary: This paper was written for two purposes. First, the authors describe a multi-level approach to gathering and evaluating the perceived service quality of the transportation system (both private and public) in Colorado. Second, the authors summarize the findings of their study, obtained through telephone surveys and focus groups.

Regarding the first purpose, the authors define "quantitative data" as data resulting from telephone surveys and "qualitative data" as findings from focus groups. This is not consistent with how the terms are used in TCRP G-6, and the authors' conclusion that "quantitative and qualitative research techniques should be used in combination for a more accurate picture of customer perceptions" is applicable to TCRP G-6 only insofar as it indicates the benefits of using a mix of performance measures.

Regarding the second purpose of the paper, there is no detail on specific modes or subsystems, and there are no reported performance measures. The findings are exclusively applicable to Colorado and not transferable to TCRP G-6 except in terms of the authors' insights on public involvement and understanding in evaluating transportation systems. These insights, which have implications for how performance measures are presented to riders, are:

- The public would like more input into the making of transportation system decisions.
- Public input is increased when "...people feel that their participation in the process makes a difference."
- The public may not understand how much building and operating mass transit systems costs, nor how expensive it is to provide public transportation for the elderly and disabled.

Comments: The authors describe a "critical incident technique," in which "service providers should focus on 'critical incidents' that make customers happy or unhappy." Relevant referenced papers are:

- Bitner, Mary Jo, Jody D. Nyquist, and Bernard H. Booms. "The Critical Incident as a Technique for Analyzing the Service Encounter." *Proceedings of Summer Educators' Conference*. American Marketing Association, Chicago, IL, April 1990.
- Bitner, Mary Jo, Bernard H. Booms, and Mary S. Tetreault. "The Service Encounter: Diagnosing Favorable and Unfavorable Incidents." *Journal of Marketing* 54, pp. 71-84. January 1990.

DeCorla-Souza, Patrick

"Tools for Metropolitan Transportation Evaluation"
TRB Paper 00-416
Transportation Research Board, Washington DC, 2000

Context: This paper summarizes the purpose, inputs and outputs of several tools developed by the U.S. DOT to help planners estimate performance measures to assess travel mode, congestion, air quality, equity and safety impacts. The paper discusses the appropriate use of each tool and explains how the tools differ in their capabilities and results.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☒ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: In general deals with all modes; compares tools that allow modal comparisons between alternatives; based on travel demand models.

Service Contracting Addressed? No

Performance Measures Identified: See the summary.

Summary: (Quoting the abstract of the submitted paper)

Post-ISTEA flexibility in use of federal funds and emphasis on social, economic and environmental objectives has increased the need for evaluation tools to supplement travel demand estimation tools. The U.S. DOT has recently developed several such tools to help planners estimate performance measures to assess travel mode, congestion, air quality, equity and safety impacts, and to compare investments in alternative modes with one another and with travel demand management strategies. The tools are categorized as follows:

- Tools for Cross-Modal Investment Evaluation
- Tools for Evaluation of Development Effects
- Other Special Purpose Tools: Highway-Rail Crossing Evaluation and ITS
- Tools under Development: for Equity Analysis, Financial Analysis, and Transportation Improvement Program Evaluation

This paper summarizes the purpose, inputs, and outputs of each tool, discusses appropriate use of each tool, and explains how the tools differ in their capabilities and results.

Comments: This paper compares tools that can be used in evaluating various alternatives based on travel demand modeling data. Performance measures reported are not specifically identified in the paper but can be observed from exhibits that provide summary output from each of the models evaluated.

Deloitte, Haskins, and Sells

Establishing a Transit Performance Measurement and Reporting System
October 1981

Context: The goal of this document is to outline ways that transit systems can design and implement transit performance measures for themselves.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: No specific systems were evaluated.

Transit Modes Considered: None

Service Contracting Addressed? No

Performance Measures Identified: None

Summary: This paper describes the process a transit system would go through to create a Transit Performance Measurement System for itself. It details four stages: feasibility analysis, design, implementation, and utilization. It emphasizes that in the feasibility and design stages, care should be taken to ensure that the measures used would directly benefit the managers and operators of the system and not just serve for funding or legislative purposes. It also makes a point to link performance measures to organizational goals and objectives so that the measures relate meaningfully to the organizational purpose. This point is made several times and is underscored in the conclusion: *Transit performance measures should be an outgrowth of organization goals, and as such, measures and standards should be set that meaningfully report on those goals.*

In establishing performance indicators, this paper details five important criteria: indicators should be linked to objectives, accessible from current records, sensitive to noticeable differences, objective, and simple. Finally, in presenting and implementing a transit performance measurement report, the paper emphasizes the point that measures are to be *used* by management, not to be filed away. Thus steps such as maximizing graphics and keeping reports up to date and publicly available should be taken if the measures are to be useful to the transit system.

Comments: This is a good overview for managers unfamiliar with the goals and mechanics of transit performance measurement. It offers a clear, step-by-step approach to implementing such a system and argues for usefulness in realistic terms.

Department of Infrastructure, Victoria, Australia

Track Record – Quarterly Performance Bulletin, Edition 6 (January-March 2001)
http://www.doi.vic.gov.au/doi/internet/transport.nsf/headingpagesdisplay/transport+publicationstrack+record
Department of Infrastructure, Melbourne, Victoria, Australia, June 2001

Context: Performance information for Victoria's train, tram, and bus services for public viewing

Applicability to G-6 Project:
- [ ] Performance-measurement program description(s)
- [ ] Characteristics of effective performance measures or measurement systems
- [ ] Performance measure examples
- [ ] Market research
- [x] Performance reporting
- [ ] Applications of technology

Transit Systems Evaluated: Private sector companies operating transit in Victoria: MetroLink Pty Ltd (trams), Connex Trains Melbourne, National Express Group Australia (trains), National Bus Company, Melbourne Bus Link

Transit Modes Considered: Urban fixed-route bus, light rail, commuter rail

Service Contracting Addressed? Yes

Performance Measures Identified:
- *Community-based:* Customer Satisfaction – Monthly surveys of users and non-users are conducted rating a number of aspects of transit, also compiled to an overall Customer Satisfaction Index
- *Service delivery:* Reliability – The proportion of scheduled services that were cancelled [except one tram operator: ratio of kilometers traveled to scheduled] (threshold for compensation is percent ran: 80 percent for trams and 92 percent for buses and trains)
- *Speed & delay:* Punctuality – on-time performance, measured at end of journey for buses and trains, trams measured at fourth monitoring point of five along route; train or tram on time if less than 59 seconds before and less than 5 minutes and 59 seconds after scheduled time; buses less than two minutes early or five minutes late (threshold for compensation is percent on time: 95 to 96 percent)

Summary: This is a bulletin for public consumption that reports the customer satisfaction and performance of transit (punctuality and reliability), comparing the measures to same times in the previous years and the preceding periods.

The franchise agreements and bus contracts, managed by the Director of Public Transport in the Department of Infrastructure, set out the overall levels of service required from each operator, tickets to be offered, maximum ticket charges, and other performance standards.

Delays, cancellations, and other service failures are recorded, then measured to the nearest 60 seconds and weighted according to the number of people estimated to be traveling on the tram or train in the time period, day of week, and direction of travel. This gives passenger-weighted minutes of delay, which are checked against performance targets set in the franchise agreements and determines whether a bonus or penalty is applicable. If an operator does not meet minimum service level requirements, compensation (usually in the form of complimentary tickets) must be provided to customers holding valid periodical tickets of greater than or equal to four weeks who traveled on the service concerned. If the operator falls below minimum service requirements, provisions in the franchise agreements trigger a 'call in' in which the operator explains and submits plans to the Director of Public transport for improvement.

Monthly surveys of users and non-users are conducted, with respondents rating a number of aspects of transit (satisfied to dissatisfied): service delivery, information services, stations/stops, passenger comfort, staff service, value for money, ticketing, and personal safety. This information is presented for each aspect and also compiled into an overall Customer Satisfaction Index.

Comments: This is a very good reporting tool, though only three performance indicators given are designed for the public.

Dobies, John J.

"Customer Information at Bus Stops"
TCRP Synthesis of Transit Practice 17
Transportation Research Board, Washington, D.C., 1996
http://nationalacademies.org/trb/publications/tcrp/tsyn17.pdf

Context: Survey of methods by which transit agencies provide information at bus stops, information program implementation issues, and the costs of providing transit information at bus stops

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Case studies in Denver, CO; San Diego, CA; Milwaukee, WI; and Sheboygan and Fond du Lac, WI

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? No

Performance Measures Identified:

- *Transit availability:* Transit information provided to customers at bus stops (qualitative)

Summary: This synthesis focuses on static information displays and printed schedules, maps, and brochures. The author describes relevant Advanced Public Transportation Systems (APTS) applications, but recognizes that these applications are being documented in other studies and are too expensive to provide in most locations. Thus, the synthesis primarily describes media that provide information in practical and cost-effective ways—from the agency's perspective—rather than media that may more successfully improve the passenger's perception of service quality.

The author identifies two major methods by which transit information is presented at bus stops: bus stop signs and supplemental displays. Most agencies display the route number/name on bus stop signs; some provide phone numbers and/or limited service availability information. Supplemental displays include display cases that contain maps, precise schedule information, fare information, and/or the agency's telephone number. Supplemental displays often contain information that changes periodically, and they are typically used only at a very small number of stops.

Comments: The synthesis provides no quantitative measure of the amount of information provided at bus stops and no quantitative measure of the relationship between the information provided and transit usage (i.e., other performance measures). Qualitative surveys and market research are cited, however. In a survey of transit managers, for example, the author found that: "For the most part, transit system managers who have been involved with on-street information programs have not relied on research to justify the programs. The need for such programs, and their effectiveness, appears to be generally accepted in the transit industry."

Doyle, Michael T., and Joshua Schank

The 2000 LIRR Report Card: Results of the Annual, Independent Rider Survey from the LIRR Commuter's Council
LIRR Commuter's Council, New York, NY, October 2000
http://www.pcac.org/reports/pdf/licard00.pdf

Context: The LIRR surveys are conducted to determine issues that are important to LIRR riders so that these issues may be addressed by the LIRR Commuter's Council.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: MTA Long Island Railroad (LIRR)

Transit Modes Considered: Commuter rail

Service Contracting Addressed? No

Performance Measures Identified: Most of the indicators below are subjective.

- *Community-based:* Customer perceptions of various service attributes
- *Transit availability:* Schedule Adequacy
- *Comfort & convenience:* Seating Availability; Announcements; Escalator Reliability; Winter Heating; Summer A/C; Seat Condition; Security (broken down by location); Cleanliness (broken down by restroom, wait area)
- *Service delivery:* Subjective; Overall Service; On-time Performance (OTP)
- *Service offered/utilization:* Home Station Hours; Peak Hour/Midday/Late-night/Weekend Service

Summary: LIRR riders assign grades to 46 indicators on an annual basis; results are generated system-wide and by branch. Indicators are added or deleted according to the situation. For example, in the 2nd quarter of 1995, cell phone usage had grown and was perceived as a possible problem. Questions regarding cell phone usage and desired cell phone policy were asked. Other questions involved whether or not riders thought service was improving and what was the most-wanted improvement. Statistical improvements from the previous year are recorded.

For this survey, 2,073 riders responded. In order to perform statistical analysis, grades are converted into numbers. A sample of 1,308 surveys were selected at random from each branch. In the sample, the proportions of each branch's data was weighted to match the proportion of branch riders versus overall riders. A 95 percent confidence level was maintained system-wide. In addition, 1,347 comments were obtained from the entire population of respondents.

Comments: These surveys of customer perceptions and the comments received from customers are extremely valuable in identifying dissatisfaction with elements of transit service, especially ones that transit management did not believe were problematic. Open-ended questions can be useful because they elicit comments and bring up issues that might otherwise not be considered.

Drosdat, Herbert

Transit Performance Measures: Their Significance in Local Funding Allocation
Prepared for the Urban Mass Transportation Administration, Washington, D.C., 1977

Context: This paper was written to evaluate the impact that performance measures have on the local funding process.

Applicability to G-6 Project:
- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: The author uses the CalTrans program as a case study.

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? No

Performance Measures Identified:
- *Service delivery:* Patronage per population served, seat hours per population served, transfer opportunities per route mile, percent missed runs
- *Economics/productivity:* Gallons of fuel per passenger, operating ratio (cost to revenue), system-wide revenue hours per vehicle, system-wide revenue miles per vehicle mile, passengers per vehicle, transit property employees per passenger, cost per passenger

Summary: This paper asserts that the utility of transit performance measures (TPMs) has been overestimated, particularly with regards to their use in allocating funds to individual transit properties. The author outlines the history of performance measures as a policy tool for transferring funds from larger governmental organizations down to individual systems, beginning with Federal allocation of funds to highway projects. The paper demonstrates that the performance measures and standards chosen can often be significantly influenced by the politics of the funding organization, resulting in partial or biased pictures of transit performance. (See FTA Office Of Policy Development, *Benefits of Transit*, review).

The author's main critique of most TPMs is that they are often hampered by a confusing and sometimes contradictory set of goals, such that the measures implemented often lacked meaning and were difficult to find data for. He concludes that, for the State of California, TPMs were not usable, and that no similar type of standardized list should be constructed for other transit systems. Such lists could prove deceptive due to their appearance of rigor and accuracy yet weak methodological infrastructure, thus resulting in misallocation of the resources and energy of transit operators.

Comments: This paper is also important within the scope of this G-6 project in that it emphasizes relative weaknesses of TPMs and advises caution against elevating them to greater-than-deserved status.

Dzurik, Andrew, and William Olsen

Development of Transit System Productivity Measures Based on Section 15 and Urban Area Environment Data
Prepared for U.S. DOT
Florida State University, 1985

Context: This paper evaluates the relationship between transit environments and system productivity in the southeastern federal funding region.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Thirty-four transit systems in the southeastern federal region

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? No

Performance Measures Identified:

- *Service offered/utilization:* Passengers per person, passengers per revenue vehicle hour, passengers per revenue vehicle mile
- *Economics/productivity:* Revenue vehicle hours per person, revenue vehicle hours per employee, revenue vehicle miles per employee, revenue vehicle miles per vehicle, fare revenue per revenue vehicle mile, cost per revenue vehicle mile, cost per revenue vehicle hour, cost per passenger, revenue to cost ratio, revenue per revenue vehicle hour, revenue per revenue vehicle mile

Summary: This paper examined the relationship between independent environmental variables in the eight-state region and the dependent efficiency and effectiveness variables in the transit systems that served them. The goal was to uncover correlations between operating environment and service level. The environmental variables considered were number of operational buses, number of transit system employees, coverage area population, coverage area in square miles, population density, percentage of low income households, percentage of zero-car households, and percentage of workers working in the central city. The dependent (service-related) variables considered are listed above.

The authors used linear regression to compare each independent with each dependent variable to reveal patterns of causation. Their three most notable findings were as follows:

- Passengers per revenue vehicle mile correlated most strongly with areas that had more than 16 percent zero-car ownership, with an with an R^2 value of 0.68.
- Cost per revenue vehicle mile correlated most strongly with systems of 150 buses or less in low population density areas, with an R^2 value of 0.70.
- Revenue per revenue vehicle mile correlated most strongly with areas that had over 10 percent zero-car household areas and had more than 25 buses, with an R^2 value of 0.78.

Comments: This paper offers quantitative insight into the relationship between service environment and service efficiency. It demonstrates the effects that different variables can have on numeric performance measures, shedding light on their relative nature.

Eccles, Robert G.

"The Performance Measurement Manifesto"
Harvard Business Review on Measuring Corporate Performance
President and Fellows of Harvard College, Cambridge, 1998

Context: Eccles presents a new performance measurement system for companies to establish in order to meet new challenges and remain competitive.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: None

Service Contracting Addressed? No

Performance Measures Identified:

Summary: Eccles writes that organizational performance must no longer be measured by financial data—new, non-financial measures such as quality and customer satisfaction are important in determining the future success of the organization. Companies must develop and implement a new performance measurement system. Although Eccles focuses upon the private sector, many of his recommendations also apply to the public sector as well.

Five activities essential for a new performance measurement system are:

1. Developing an information architecture
2. Putting the technology in place to support the architecture
3. Aligning bonuses and other incentives with the new system
4. Drawing on outside resources and
5. Designing an internal process to ensure the other four activities occur

Also, the "careful preparation, perseverance, and the conviction of the CEO" is needed to implement the new performance measures. In addition, Eccles mentions that "what gets measured gets attention, particularly when rewards are tied to the measures." (*This idea may be controversial in the public sector, especially if measures are not under the complete control of the employees.)*

Eccles emphasizes the importance of customer satisfaction and states that "strategies that focus on quality will evolve naturally into strategies based on customer service." Performance will be not only be measured by operational metrics such as defect rates but by customer-oriented measures such as customer retention rates, market share, and perceived value of goods and services.

Benchmarking: Eccles defines benchmarking as "identifying competitors and/or companies in other industries that exemplify best practice in some activity, function, or process and then comparing one's own performance to theirs… In contrast, internal yardsticks that measure current performance in relation to prior period results, current budget, or the results of other units within the company rarely have such an eye-opening effect." Eccles argues that it is more important for an organization to compare itself to other organizations rather than its own historical performance.

Information Architecture: Eccles defines information architecture as the "categories of information needed to manage a company's businesses, the methods the company uses to generate this information, and the rules regulating its flow." When implementing a new performance measurement system, the organization's entire information architecture needs to be rethought, due to new data needs that will arise from new performance measures. Eccles also suggests that a "new corporate grammar" be created to articulate new corporate goals and strategies

Data: Who will be responsible for the data required for the new performance measurement system? One approach is to assign a senior executive to each of the measures and hold him or her responsible for developing its methodologies. Another approach is to create a new unit focused on one measure and then gradually expand the unit for other measures. (*This concept could be applied to smaller transit agencies that don't have resources for a full-blown performance measurement system. They could start with a few measures and then add to them gradually*.)

Finally, Eccles describes the new performance measurement system as an ongoing and evolving process—he calls it a "revolution that never ends."

Comments: The target audience for this article is not public agencies. However, many of the concepts regarding performance measurement could be applied to the public sector (e.g., transit agencies).

Echols, James, and D.H. James

"Public Transportation Operating Standards"
TRB Special Report 144, Issues in Public Transportation
Transportation Research Board, Washington, D.C., 1972

Context: This document is actually two separate articles bundled into one, both discussing operational standards. The first section describes the San Antonio transit system's successful performance standards program. The second section discusses why operators may be reluctant to impose standards and what role an external consultant can play in the process.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: The San Antonio transit system

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? No

Performance Measures Identified: See the summary.

Summary: This article is divided into two separate sections, each authored by different people. The first section is an explanation of the performance standards used in San Antonio. These standards are mostly geared towards evaluating the potential demand and land use conditions around a proposed new route. For example, the article specifies that there must be an average of three family dwelling units per acre in the area to be served. These types of standards work well for planning and management, but are less directly applicable to operator services, such as determining the appropriate standard for revenue miles per vehicle.

The second section of the article is more of a treatise on why transit consultants should be used to set performance standards. The main argument is that operators often resist standards because they think too much attention will be paid to them from outside sources and that they do not accurately reflect the nature of their service. Thus an objective, outside consultant should be hired to mediate the public's demand for knowledge and service and the needs of the system operators.

Einstein, Ned

"Sequencing Decisions In Paratransit System Design"
Proceedings of the 2001 Bus and Paratransit Conference
American Public Transportation Association, Calgary, Alberta, 2001

Context: Einstein examines the current state of complementary paratransit services in terms of efficiency, system reliability, customer complaints, and legal issues resulting from inadequate customer service. Einstein attempts to address the growing problems of complementary paratransit services using a model tailored to the unique service delivery issues involved in transporting special needs clients.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: Urban demand-response (specialized)

Service Contracting Addressed? No

Performance Measures Identified:

- *Comfort & convenience:* Passenger load time efficiency for passengers using wheelchairs
- *Service delivery:* Scheduling and dispatch, response of system design to scheduling pick-up and drop-off sequences that involve transporting wheelchair occupants

Summary: Despite an army of lead agency management personnel and an arsenal of advanced technology, complementary paratransit services have yet to get the "bugs worked out." Einstein illustrates with a very simple scenario how the basic operation of a paratransit service can become fraught with problems. Einstein applies this scenario to his model found in his text *Paratransit System Decision-Making: Interrelationships and Sequencing* in an attempt to identify the many improperly coordinated variables that contributed to it. The steps laid out in his model and its application to the accident scenario described in this article lays the groundwork for assessing the performance of paratransit services and delineating the origins of its inefficiencies. Einstein underscores common practices in paratransit services that result in inefficiencies and identifies the level of management within an organization wherein the responsibility for remedying inefficiencies can be assigned. Einstein's model and its application to real-life scenarios in paratransit operations could be used to develop a standard for performance measurement and accountability.

European Commission

QUATTRO Final Report: Synthesis and Recommendations
Project funded by the European Commission under the Transport RTD Programme of the EU's 4th Framework Programme for Research, Technological Development, and Demonstration
European Commission, June 1998
http://europa.eu.int/comm/transport/extra/final_reports/urban/quattro.pdf

Context: Final report of the *Qu*ality *A*pproach in *T*endering/Contracting Urban Public *Tr*ansportation *O*perations (QUATTRO) project

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s) (to a limited extent)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology
- ☒ Other: Survey techniques and guidelines

Transit Systems Evaluated: Examples from several European systems

Transit Modes Considered: All, very generally

Service Contracting Addressed? Yes

Performance Measures Identified: See the summary.

Summary: The intent of the QUATTRO project is to "develop and improve quality in urban public transport tendering, contracting, and monitoring procedures." The project includes 20 partners from eight European Union countries, plus Norway, Poland, Hungary, and the Baltic states.

The objectives of the QUATTRO project consisted 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 or interested in contracting and performance monitoring in urban public transportation with a strong focus on quality.

Four classes of service quality are described in detail in this report. These classes are

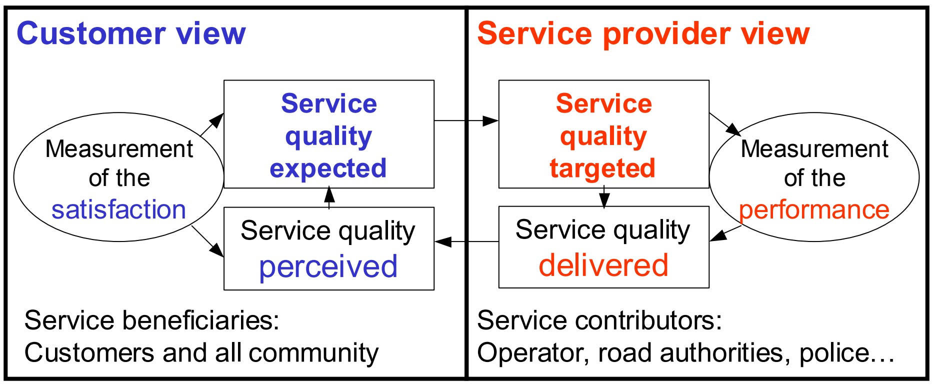
- *Expected Quality*. "This is the level of quality anticipated by the customer and it can be defined in terms of explicit and implicit expectations. The level of quality expected by the passenger can be defined as the sum of a number of weighted quality criteria. Qualitative and quantitative surveys 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 the following table. These classes form a "quality loop" wherein the gaps correspond to areas where service improvements are required. A figure depicting the "quality loop" follows.

The report 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.

Figure 3. Quality Loop



The report includes much detail on the different types of surveys that can be used to 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 the table above. Charters should be unconditional, easy to understand, meaningful, easy to refer to, and easy to fulfill. The second table below provides an example of charter targets.

Comments: The table of service quality is characterized by distinctions and components not encountered in other literature reviewed to date. These include, for example, accessibility between taxis and transit, the four classes of service quality, more detail on quantifying pollution, and the determinants of information quality under abnormal operating conditions.

Service needs for mobility-impaired customers are classified under Customer Care, not Accessibility, Availability, or other categories where they have been addressed in most of the literature reviewed to date.

There is much relevant information in this report. This summary primarily covers Section 3 of the report. Section 5 and the appendix contain information about quality in service contracting.

Hierarchy of Quality Determinants in Public Transportation

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

Example Content of Customer Charter of Commitment

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%

Everett, P.B.

"Service and Performance Indicators"
Consumer-related Issues in Public Transit: Workshop Proceedings
Transportation Research Board Unpublished Report No. 7
Transportation Research Board, 1978

Context: Workshop

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated:

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? No

Performance Measures Identified:

- *Transit availability:* Percent of population with 0.25 mile of existing route, maximum allowable headway, maximum percent of riders required to transfer
- *Service delivery:* Maximum peak-load factor, percent of bus on-time
- *Speed & delay:* Average wait time for passengers transferring

Summary: This workshop dealt with how transit agencies developed service and performance standards. Some of San Diego's transit service standards that were adopted in 1978 are summarized in the table below. The standards are tailored to the conditions in San Diego. For example, San Diego's good weather and hilly conditions allow for longer wait times but shorter walking distances.

Examples of Service Standards Adopted by San Diego

Objective	Performance Criteria	Service Standards
Low Walk Time	Percent of population within 0.4 km (0.25 mi) of existing route.	70 percent
Low Wait Time	Maximum allowable headway	Off-Peak: 60 min
	Percent of buses on time Peak: 30 min	Peak: 90 percent Off-Peak: 95 percent
Low Transfer Time	Maximum percent of riders required to transfer	40 percent
	Average wait time for passengers transferring	1/3 of connecting routes headway
Low Number of Standees	Maximum peak-load factor	Peak: 1.5 Off-Peak: 1.0

Federal Highway Administration

Transportation User's Views of Quality
1995 Nationwide Personal Transportation Survey
Federal Highway Administration, Washington, DC, December 1997

Context: This document reports results from the 1995 Nationwide Personal Transportation Survey pretest.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology
- ☒ Other: Level of transit use, and some insights into transit issues from transit users

Transit Systems Evaluated: None

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified: None

Summary: This report is a summary of the results of the 1995 Nationwide Personal Transportation Survey (NPTS) pretest. This was a national telephone survey to understand the public's views regarding the transportation services it receives. The national sample included over 4000 adults. This review focused on the transit related information provided.

Approximately five percent of survey respondents indicated that transit use was their main mode of travel. In general, local (urban) bus service and local rail (urban) transit service were rated positively (rating of good or excellent) by 64 percent of respondents. Connections to other modes for the "highway-related elements" (possibly implying the automobile mode) were also rated good or excellent by 64 percent of the respondents. Transit users ranked major highway delay negatively about twice as likely as automobile drivers. The survey also reports that not surprisingly, significantly fewer of those households without vehicles agreed that traveling by private vehicle gives them the freedom to go where and when they need to go. Female respondents were more concerned about being dependant on a car than males, but overall, 60 percent of respondents did not think that being dependant on a car was a problem. Several cross-tabulations between gender, age group and kind and size of metropolitan area that one lives in are presented. As an example, the results indicate that concerns about crime against motorists and air pollution are more prevalent in big cities as compared to people who live outside metropolitan areas over one million.

To better understand the interests of those who use transit, the study identified the levels of use of transit for those who responded that transit was their primary mode of travel (approximately five percent of total respondents). Of the total respondents approximately 2000 indicated that there was no transit available where they lived. In areas where transit is available, about 76 percent say they never use it. A significant number of people, particularly those whose predominant mode of travel is pedestrian and automobile passenger, indicated that they use transit two or more days per week or less frequently. The survey also indicates that those who consider themselves transit users constitute only about two-thirds of the group that say they use transit two days a week or more. The others are those who usually drive or are a passenger. When all time categories are summed, those who say that they primarily use transit constitute about 27 percent of transit riders with usual auto users who use transit only on an incidental basis constituting about 62 percent. Walkers accounted for about nine percent. The summary of the report states that there is substantial support for transit among users. Main reasons for use were convenience, reduced costs and stress from driving. The strongest negatives were concerns about cleanliness and waiting. Cost was not identified as a major concern.

Comments: The paper cautions readers about interpreting survey results because the survey did not include adults without telephones where they live. Telephone ownership, or the lack of it, may in turn be related to factors such as income and age.

Federal Transit Administration, Office of Policy Development

Transit Benefits 2000 Working Papers
U.S. DOT, Washington, D.C., 2000

Context: This FTA paper presents recent "state-of-the-practice" research on measuring the economic benefits and performance of transit systems. It focuses on the congestion mitigation and economic impacts of transit and is intended to educate operators, policymakers, and academics on progressive trends in performance policy analysis.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Six corridors were evaluated. They were the Metro Red Line in Washington, D.C., the Midway Orange Line in Chicago, the St. Louis North Hanley light rail corridor (LRC), the Sacramento Butterfield LRC, the Dallas Park Lane LRC, and the Oregon Gateway LRC (these names do not necessarily match local usage).

Transit Modes Considered: Urban fixed-route bus, light rail

Service Contracting Addressed? No

Performance Measures Identified:

- *Service delivery:* Travel time (in minutes), vehicle miles traveled, free flow travel rates (miles per hour)
- *Service offered/utilization:* Passenger miles per day, average trip length
- *Economics/productivity:* Operating expense per passenger mile
- *Vehicular capacity:* Vehicle occupancy (person car equivalents)
- *Speed & delay:* Congestion cost per capita/per driver, delay per capita/per driver, wasted fuel per capita/per driver

Summary: This report addresses the historical trend in performance measurement of transit systems to use the traditional "performance framework" of efficiency, effectiveness, and cost-effectiveness to evaluate the merits of Federal transit expenditures at the national aggregate level. It highlights recent advancements in performance measurement that demonstrate that such measurements alone often produce an incomplete picture of the benefits of Federal investment in transit. They also tend to be heavily biased by political perspectives from the 1980s that sought to reduce the Federal budget by cutting funding to "leaky" or "swollen" transit systems on the grounds that Federal funds encouraged inefficiency and fiscal dependency.

The report is divided into five main sections, four of which are discussed in this review. The first uses 1995 NPTS data to estimate the cost, subsidy, and benefit of transit for three groups: the Basic Mobility group comprising the poor, elderly, and youth; the Locational Efficiency group comprising working adults with no automobiles; and the Congestion Relief group comprising working adults with one or more automobiles who choose to use transit. The net per trip benefit in auto costs, consumer surplus, and travel time was $6.44 for the Basic Mobility group, $9.82 for the Locational Efficiency group, and $3.07 for the Congestion Relief group.

The second section uses recent algorithms to compute the impact of transit on delay and costs incurred from congestion in six major corridors nationwide. It found that transit saves over 60,000 travel hours per day in those corridors, for a total savings of $225 million yearly.

The last two sections predict the aggregate economic impact of increased transit presence nationwide and the commercial property benefits of transit. The report found that, for every 1 percent change in transit presence, there is an average $23 million annual additional economic benefit to local metropolitan areas and an aggregate $3 billion annual additional economic benefit nationwide. Regarding commercial property, the report found that, for every 1,000 foot decrease in the distance to a Metro station, there is an average increase in property value of $2.29 per square foot.

Comments: This report offers an important perspective not found in any of the other literature reviewed. The overwhelming policy message of this report is that the rising costs of transit service during the 1970s and 1980s were not examples of an inefficient industry fed by Federal largesse but rather examples of an industry making massive but costly improvements to its infrastructure and quality of service. The new approaches to performance measurement that it sets forth are both timely and rigorous, providing strong support for this policy perspective.

Federal Transit Administration, Office of Safety and Security

State Safety Oversight Program: Annual Report for 1999
Federal Transit Administration Report DOT-FTA-MA-90-5006-00-1
Volpe National Transportation Systems Center, Cambridge, MA, September 2000

Context: Report on state activities to implement ISTEA regulations that require states to oversee rail transit safety and security

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: 32 rail operators

Transit Modes Considered: light rail, heavy rail, cable car, automated guideway transit, inclined plane, monorail

Service Contracting Addressed? No

Performance Measures Identified:

- *Safety & security:* passenger fatalities, employee fatalities, other fatalities, passenger injuries, employee injuries, other injuries, number of collisions, number of derailments, number of rail grade crossing accidents, number of fires, number of other reportable incidents (slips, trips, and falls; car door injuries; injuries while boarding or alighting; injuries on escalators, stairs, and elevators; medical emergencies), cause of events (percent by type), property damage from accidents, number of positive drug/alcohol tests, number of crimes (percent by type)

Summary: This report presents summary information resulting from the first year of mandated state oversight of rail transit safety and security. It also discusses challenges in using the information. For example, the information presented in the report does not facilitate peer review, because no information is provided about the environment an agency operates in (e.g., labor agreement provisions; climatic conditions that affect fuel and maintenance costs). The FTA is concerned that it does not have the proper statistical data necessary to carry out its safety mission.

Another issue is one of definition. Definitions impact the use of the data in at least two ways. First, better definitions of terms are needed to resolve situations that may result in duplicate reporting (e.g., when a fatal accident triggers two duplicate reports, one because of the accident, and the other because of the fatality). Second, different agencies report data in different ways. A good example is fare evasion. When an arrest is made, fare evasion is reported as a transit crime, but when only a citation is issued, no crime record is created. Because the number of fare evasion arrests tends to overwhelm other kinds of crimes, differences in transit policing practices may create unwarranted impressions of comparative system security, based solely on the difference in the number of reported crimes.

An interesting fact that is mentioned is that damage to rail property as the result of an accident is only one aspect of the accident's cost. Injury claims, legal fees, the cost of accident investigation and corrective actions, increased insurance costs, among a host of other costs, all contribute to the total cost. The report quotes a study that found that when all of these costs are accounted for, 5% of rail transit operating budgets typically go to the costs of accidents.

Fielding, G.J.

Managing Public Transit Strategically
Jossey-Bass Publishers, San Francisco, CA, 1987

Context: Book on managing public transport

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None specifically

Transit Modes Considered: All

Service Contracting Addressed? Yes

Performance Measures Identified: See the table in the Summary section.

Summary: This book on managing public transport, which was published in 1987, discusses changing goals, measuring and monitoring, effective budgeting and financing, improving labor efficiency, developing labor contracts, planning, and marketing. The chapter related to the TCRP G-6 research is the chapter on measuring and monitoring.

The book contains three main ideas for measuring and monitoring transit:

- Only a few indicators are needed to monitor the important dimensions of transit performance.
- Efficiency, effectiveness, and overall indicators are the most helpful for management.
- Improving performance is management's responsibility. External agencies may require performance monitoring and may designate indicators for the measurement; however, improvements must be left to internal managers.

Efficiency is defined as how well factors such as labor, equipment, facilities, and fuel are used to produce outputs as represented by vehicle hours or miles of service. Effectiveness is described as the measure of the consumption of transit output in addition to the impact of transit on societal goals such as reducing traffic congestion. Overall measures therefore integrate the two, with measures such as cost per passenger and ratio of revenue to the cost of production.

Three types of statistics are used to produce the performance indicators: Service Input (quality of resources expended to produce the service); Service Output (quantity of service produced, in non-monetary terms); and Service Consumption (amount of service used). It is indicated that a wide variety of performance measures can be derived from these statistics, in three categories: cost efficiency, service effectiveness, and cost effectiveness. It is cautioned, however, that in selecting performance measures, consideration must be given to the availability and reliability of the data, with financial statistics the most reliable and passenger miles of travel the least. The key to the successful administrative use of performance indicators is contended to be keeping the list small and easily understood.

The cost efficiency category includes transit efficiency, labor efficiency, vehicle efficiency, fuel efficiency, maintenance efficiency, and overall cost efficiency. The service effectiveness category includes utilization of service, revenue generation, operating safety, public assistance, and social effectiveness. The following table, reproduced from the book, gives the recommended performance indicators.

Recommended Performance Indicators

Performance Dimension	Recommended	Good Alternative
Cost Efficiency	Revenue vehicle hour per operating expense	Total vehicle miles per operating expense
Service Utilization	Unlinked passenger trips per revenue vehicle hour	Unlinked passenger trips per revenue vehicle mile
Revenue Generation	Corrected operating revenue per operating expense	Operating revenue per operating subsidy
Labor Efficiency	Total vehicle hours per total employees	Revenue vehicle hours per operating employee
Vehicle Efficiency	Total vehicle miles per peak vehicle	Total vehicle hours per peak vehicle
Maintenance Efficiency	Total vehicle miles per maintenance employee	Total vehicle miles per maintenance expense
Safety	Total vehicle miles per collision accident	Total vehicle miles per dollar collision and liability expense

Fielding, Gordon, and Roy Glauthier

Development of Performance Indicators for Transit
Institute of Transportation Studies, University of California, Irvine, CA, 1977

Context: This paper, dating from the late 1970s, attempts one of the first creations of a set of uniform performance measures on large scale.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Forty-seven systems in California and five systems in Washington State were evaluated.

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified:

- *Service delivery:* Revenue vehicle miles per vehicle, total vehicle miles per vehicle, revenue vehicle hours per vehicle, revenue passengers per vehicle mile/per vehicle hour
- *Service offered/utilization:* Percent population served, revenue passengers per service area population
- *Economics/productivity:* Revenue vehicle miles per employee, total vehicle miles per employee, revenue vehicle hours per employee, operating expense per seat mile/per revenue vehicle mile/per total vehicle mile/per revenue vehicle hour, energy consumption per revenue vehicle mile/per total vehicle mile/per revenue vehicle hour, operating expense per total passenger/per revenue passenger/per passenger mile
- *Vehicular capacity:* Total passengers per vehicle

Summary: This paper lays out the now-traditional framework of service inputs, service outputs, and service consumption. It puts emphasis on efficiency and effectiveness indicators as a means of measuring compliance with the performance standards established by a system’s goals. The paper tries to minimize the effect of uncontrollable environmental variables such as population size, instead choosing to focus on operator-centric measures that are within the control of transit managers. It then provides a detailed discussion for each performance measure cited above, discussing their measurement strengths and potentially confounding factors.

Comments: The paper will provide a strong source document for the performance review worksheets, as it provides a detailed discussion of the pros and cons of many common performance indicators.

Fielding, G., R. Glauthier, and C. Lave

"Performance Indicators for Transit Management"
Transportation, 7(4), pp. 365-379
Elsevier Scientific Publishing Company, Amsterdam, 1978

Context: Journal article by academics based on work done for the U.S. Urban Mass Transport Administration

Applicability to G-6 Project:
- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Demonstrated indicators for 46 California bus operators

Transit Modes Considered: Urban fixed-route bus, urban demand-response (general public)

Service Contracting Addressed? Yes

Performance Measures Identified: (1=efficiency, 2=effectiveness, 3=overall measure)
- *Transit availability:* Percent of population serviced (2)
- *Service offered/utilization:* Revenue passengers per service area population (2); total passengers per vehicle (2)
- *Economics/productivity:* Revenue vehicle hours per employee (1); revenue vehicle hours per vehicle (1); operating expense per revenue vehicle hour (1); revenue passengers per revenue vehicle hour (2); operating expenses per total passenger (3); operating expense per revenue passenger (3)

Summary: The paper assesses transit performance by qualitative indicators based on the goals of efficient and effective service. The authors review 21 performance indicators from previous studies and establish three efficiency, four effectiveness, and two overall indicators.

The paper reviews previous literature on transit performance evaluation, back to the U.S. National Committee on Urban Transportation reports (1958), and concludes that the rationale for the development of performance indicators based on efficiency and effectiveness is established by the previous literature. It is commented that performance evaluation requires the establishment of clear goals for transit and the specification of indicators appropriate to those goals. Efficiency indicators are defined as measures that rate the processes by which transit services are produced, while effectiveness indicators compare the service actually provided to the objectives or outputs intended. That is, efficiency is concerned with "doing things right" and effectiveness is "doing the right things."

It is stated that the performance indicators selected in the paper are not final, as circumstances such as improved data, emphasis on other goals, or local conditions might require other measures. The paper discusses the problems with the estimations of passengers: Based on boardings, the total passengers will be overestimated due to transfers; however, basing the number of passengers on revenues will underestimate the total due to free or reduced fares for pensioners and other classes of passengers. It is concluded that, when available, linked trips should be used.

The paper addresses the use of performance indicators, advising that management should select the indicators they feel are appropriate for operators' size and local conditions. The indicators could be compared to public operating and financial data, other operators, or published "par" values for different types and sizes of transit operation.

Foote, Peter J., Darwin G. Stuart, and Rebecca Elmore-Yalch

"Exploring Customer Loyalty as a Transit Performance Measure"
Transportation Research Record 1753
National Academy Press, Washington, DC, 2001

Context: As measured by customer satisfaction surveys in 1995, 1997, and 1999, there was a significant increase in the number of riders with positive attitudes toward the CTA. Specific areas of improved customer satisfaction are reviewed, with emphasis on a three-part index of customer loyalty. Investigation of the three basic dimensions of improved customer loyalty to CTA (overall satisfaction, likelihood of continued riding, likelihood of recommending to others) is described. The loyalty index is explored as a useful summary measure of public transit's ability to attract choice riders.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☒ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Chicago Transit Authority (CTA)

Transit Modes Considered: Urban fixed-route bus, heavy rail

Service Contracting Addressed? No

Performance Measures Identified: See the summary.

Summary: The importance of customer satisfaction to transit is most evident in the challenge of drawing choice riders away from the private automobile. This paper explores whether there is a useful role for the concept of "customer loyalty", as a transit performance measure. In private industry, it has been found that only the most satisfied customers remain truly loyal. What does it take for choice riders to become very satisfied with public transit?

As a result of CTA initiatives and policy actions, especially regarding fare policy, significant improvement was found, between 1997 and 1999 in CTA's household travel market share, customer travel frequencies, and the share of customers choosing to ride CTA. In 1999, a significant increase in the number of households with at least one person who rode CTA in the prior week was observed, compared to 1997. While many of the new riders use CTA infrequently, the broadening of CTA's household market base contributed to a 5.5% increase in ridership (as measured by daily boardings) experienced since 1997 (+9.0% rail, +3.8% bus). The number of persons riding infrequently (1-4 days per week) increased from 37% in 1995 to 49% in 1999.

The increased in new riders has paralleled expansion in choice markets. Specifically, there has been a significant increase in the proportion of riders who own a car but prefer using transit.

After evaluating CTA's performance on individual bus and rail service attributes, three questions were asked of all survey respondents, to measure overall satisfaction and loyalty: (1) "How satisfied are you overall with CTA (bus/rail) service?" (2) "How likely are you to continue riding CTA?", and (3) "How willing are you to recommend CTA (bus/rail) service to a friend, family or co-worker?" These three questions, worth 5 points each, form the basis for CTA's customer loyalty index. The possible range of scores, therefore, is from 3 to 15, the later being a perfect score.

Significant improvements were found on all three overall satisfaction and loyalty measures. The average customer loyalty index (average combined score) increased significantly (7.7%), from 11.7 in 1997 to 12.6 in 1999. Customer loyalty ratings were examined by transit dependent vs. choice riders (had a car available or voluntarily gave up a care to ride transit), and it was found that choice riders are significantly more loyal than dependent riders.

Comments: The findings of the research are somewhat confounded by parallel findings that the customer service loyalty index did not significantly improve for infrequent riders. As the paper points out, improvements in satisfaction in specific transit service attributes, due to CTA management initiatives in regard to fare policy, appear to be the major factor in the parallel increases in customer loyalty.

Forkenbrock, David J.

"Transit Performance Measures and Local Objectives: State-Level Policy Considerations"
Transportation Research Record 813
National Academy Press, Washington, D.C., 1981

Context: The author presents various criteria for transit resource allocation by states. The implications of each criterion are discussed.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified: See the summary.

Summary: Five categories of resource allocation criteria for public transportation are presented by the author. They are:

- *Efficiency maximization* – Efficiency maximization seeks to do just that: promote economic efficiency. The agencies that maximize the use of their resources the most will receive the most funds. However, this criterion ignores environmental conditions of each agency and local desires, needs, and preferences.
- *Uniform service quality* – Uniform service quality takes into account cost differences from agency to agency in providing transit service. Where costs are higher, more funds would be allocated. The disadvantage with this criterion is that a large amount of funds might be allocated to inefficient agencies.
- *Equal funding for similar-sized areas* – Equal funding for similar-sized areas is a politically favorable criterion. The following assumptions need to be made, however:
  - The demand for transit is uniform
  - The costs of service provision are similar
  - All agencies are operated with equal efficiency.

  Because these conditions are unlikely to be met, this criterion may not be useful.
- *Meeting the needs of the transportation-disadvantaged* – Meeting the needs of the transportation-disadvantaged is considered to be more valuable than meeting the needs of other populations. Demographic and socioeconomic measures become important under this criterion; economic efficiency and service quality could suffer.
- *Responsiveness to local preferences* – The final criterion focuses on satisfying local needs and preferences. The planning process receives more emphasis than service quality with this criterion. Furthermore, both service quality and economic efficiency could differ greatly from agency to agency within a particular state.

The author describes two different funding types—developmental funding and sustenance funding—and emphasize the diverging perspectives of the state and local communities. States desire efficient transit systems and have a propensity to invest in those systems that produce more output (e.g., ridership). Local communities need a steady source of funding to operate existing services and additional funds for initiating or expanding service. By using performance-based funding, the author contends that agencies will be able to estimate future funding levels by reviewing their own performance and states will be able to encourage efficient provision of transit service.

Comments: The only “measures” mentioned specifically are ridership and population. However, details of how they would be used and their definitions are not provided by the authors. Also, the method to reconcile the various divergent criteria was not clear.

Forkenbrock, David J., and Glen E. Weisbrod

"Guidebook for Assessing the Social and Economic Effects of Transportation Projects"
NCHRP Report 456
Transportation Research Board, Washington, D.C., 2001
http://trb.org/trb/publications/nchrp/nchrp_rpt_456-a.pdf

Context: The authors undertake a comprehensive assessment of the social and economic impacts of transportation projects for the NCHRP. Each impact is defined and related issues are examined. Also, analysis steps and methods are described. All transit modes are considered, as well as other modes of transportation.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified: See the summary.

Summary: The authors focus on the comprehensive assessment of impacts of transportation projects. They state that the assessment process is complex due to the fact that (1) benefits to users versus other community residents must be balanced and (2) various tradeoffs among community residents and population groups occur because preferences and opinions of different residents and groups differ. The authors believe that the importance of community involvement in the impact assessment process cannot be overstated. Also, distribution of various effects should be considered. In terms of the mechanics, the authors warn that double-counting and excessive aggregation of measures should be avoided.

The ultimate purpose of transportation system changes is assumed to be enhanced quality of life. The authors analyze transportation system effects and social and economic effects; although each effect is analyzed separately, the authors emphasize that numerous linkages among effects in each category and between transportation system effects and economic effects exist. For each effect, the steps in the analysis and possible analysis methods are mentioned.

The traditional transportation system effects considered in the report include changes in travel time, safety, and vehicle operating costs. Other transportation system effects include transportation choice and accessibility. The authors mention that accessibility is affected by the other factors. Four of the effects are described as follows:

- *Changes in travel time* – In many projects, most of the user benefits will be due to travel time changes. These changes can be decreased mean travel time and/or reductions in travel time variability. Because savings in travel time can be used for activities, the opportunity costs of travel are reduced. Transportation factors affecting travel time include expansion of road system capacity and improved traffic controls, construction of a new road, and projects that reduce congestion. Special issues related to travel time include valuing travel time, travel time budgets, travel time variability, impact areas, and equity concerns.
- *Safety* – Safety measures indicate rate of fatal, injury, and property-damage-only crashes. Transportation factors affecting safety include capacity expansion and congestion reduction; changes in signalization, turning lanes, and passing restrictions; and roadway improvements.

Special issues relating to safety include factors contributing to crashes, data limitations, definition of impact area, and equity concerns.

- *Transportation choice* – This category of effects represents the quality and quantity of transportation options available to residents. The options are important because it helps communities achieve equity goals; also, back-up options for those who drive are included in this category. Transportation factors affecting choice include: increased traffic due to road upgrades (which can cause dangerous conditions for pedestrians and bicyclists); street widening (which can create barriers for pedestrians and bicyclists); and transportation projects (which can displace or disrupt facilities such as bicycle trails). The special issues related to transportation choice include: equity concerns, network analysis, facility safety, and security.

- *Accessibility* – The authors define accessibility as the "relative ease with which desired destinations can be reached." They differentiate between area-wide and local accessibility. Area-wide accessibility depends on the availability of transportation services from other locations to a specific destination. Local accessibility refers to how easily individual travelers can get to a specific destination. Transportation factors affecting accessibility include improvements to public transit (which can increase travel options); improved road capacity and traffic control (which can reduce travel times); any type of transportation infrastructure and traffic control (which can represent a physical barrier to vehicles and pedestrians); and disruption of access to businesses and other destinations during construction. Special issues mentioned under this effect include connection between changes in access and land use patterns/urban form, impact area definition, system performance and accessibility, and equity concerns. Different types of access require different calculation methods: access to basic services, access to quality-of-life destinations, access to markets, and local access. The four measures that can be used to quantify the accessibility-related effects are change in travel time, change in travel costs, change in the number of choices, and change in market reach.

Social and economic effects presented by the authors include:

- *Community cohesion* – This effect describes the "pattern of social networking within a community." The effects of transportation projects on community cohesion may be difficult to quantify. The factors affecting it would include household and business relocation, structural barriers, and indirect effects of psychological barriers. Special issues include impact area definition and equity concerns.

- *Economic development* – Economic development refers to increased economic activity (e.g., business start-ups and expansions). Economic development leads to enhanced quality of life by increasing income (wage levels), job choices, activity choices, stability of jobs and income, and amenities. The factors affecting economic development include business travel costs, business market reach, personal travel costs, job access, and quality of life. Special issues include relocation versus growth, definition of the impact area, business activity, capital investment, tax-base issues, analysis assumptions, double-counting, and equity concerns.

- *Traffic noise* – Unwanted sounds generated by traffic arise from tire/pavement interaction, vehicle engines, and vehicle exhausts. (W*hat about horn-blowing*?) Transportation factors affecting traffic noise include speed/volume/proportion of trucks, stop-and-go-traffic versus free-flow traffic, and sound intensity. Noise can affect residents inside their homes, certain activities that require a tranquil environment (e.g., schools and worship houses), socializing process, and pedestrians. Special issues include receptor location, weighted decibels of various pitch sounds, existing resources and regulations, and equity concerns.

- *Visual quality* – Constructing new structures may cause sizeable elements to be added to the existing landscape or block views of desirable landscape. Also, removal of building and landmarks during transportation projects may change the visual quality of a community. Special issues include the subjective nature of valuing visual quality and impact area definition.

Comments: Though the authors focus on transportation project selection methods, the impacts presented in this report may be suitable as community-oriented performance indicators and appropriate for other purposes as well.

The authors do not explain how the transportation system effects and social and economic effects were selected. The effects selected are a small set of a larger population of potential effects.

It was surprising that environmental effects such as air pollution were not included in this report. Certainly, the environmental impacts (either positive or negative) of transportation projects on the community's health and well-being can significantly influence a community's quality of life.

Freytag, Herbie, and Bruno Parolin

"P-Trips: A GIS System for Regional Transit Accessibility Analysis"
Proceedings of the Transportation 2000 AITPM International Conference
Australian Institute of Traffic Planning and Management, Gold Coast, Queensland, Australia, June 2000

Context: Transit accessibility model developed and applied in Austria that the paper's authors hope to apply next in Australia

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology
- ☒ Other: Model development

Transit Systems Evaluated: Unspecified system in Austria

Transit Modes Considered: Urban fixed-route bus, rural transit (general public), heavy rail, light rail, commuter rail

Service Contracting Addressed? No

Performance Measures Identified:

- *Transit availability:* Accessibility (service connectivity)
- *Speed & delay:* Travel time between points

Summary: A person's level of accessibility is an important way of assessing service quality and utility. It has been traditionally been measured by:

- Existence of access to specific urban functions by transit (e.g., the number of travel alternatives, if any)
- Access opportunities to transit service (by car, by driving, etc.)
- Transfer times, wait times, travel times, service frequency
- Service availability for off-peak trips

Techniques used to measure accessibility include service coverage (by buffering stops or routes) and models of service connectivity. The latter include:

- *Transport networks* – A single GIS link provides attributes about all transit services along that link.
- *Transit networks* – Routes are coded as individual links, with transfer opportunities occurring at shared nodes.
- *Diachronic networks* – Routes are coded as individual links, with transfer opportunities coded as a dummy links that introduce a transfer time element.
- *Stop-based models* – The route structure is ignored; rather, a database of transit arrival and departure times at stops is maintained. Transfer times are modeled by assigning a generic transfer time to a particular stop that applies to all possible combinations of transfers.

The P-Trips model is a stop-based model. This form of model was chosen because the process of providing data is greatly simplified while maintaining the ability to perform a variety of analyses. Unlike the other model types, there is no need to trace out routes and route variations in GIS. The model requires information on transit stop locations, population by area (e.g., TAZs or census blocks), and schedules (arrival and departure times at stops) for each transit trip operated. Issues associated with this kind of model that were addressed include the following:

- Population data are often provided for large areas (e.g., census blocks) while the actual locations of people may be in more concentrated areas. This was addressed by identifying actual locations of residential population from aerial photos or digital maps and distributing the larger area's population to these smaller areas.
- Overlapping stops have "exclusive" and "effective" (shared) coverage areas. One needs to account for both areas when estimating the number of people served by a particular transit service.
- There may be multiple ways to get from Point "A" to Point "B," many of which are not realistic in the sense that passengers would choose to use them because of the length of time required. This was addressed by ignoring trips longer than a user-defined percentage (e.g., 20 percent) of the minimum trip length.

The model has been applied on a data set containing 42,000 residential zones, 28,000 transit stops, 32,000 transit services, and a 750,000-record schedule database.

Comments: The P-Trips model falls into the same category as the Public Transport Accessibility Level (PTAL) index developed in London and the Florida Transit Level of Service (TLOS) Indicator in that it addresses both spatial and temporal aspects of transit accessibility. It assesses walking access in terms of air distances from a transit stop and does not address the pedestrian environment at all. It provides a measure of travel time between points that the other models do not currently provide directly. Performance measures are more time-oriented (locations within a given travel time of a point) than coverage-oriented (number of people within a given travel time of a point). The job end of the trip is treated as a potential destination from a residential area. No information is provided on the amount of time it took to perform the analysis or to prepare data for use with the model.

Fuller, Ernest

Performance Measures for Public Transit Service
Prepared for the California Department of Transportation
Sacramento, CA, 1978

Context: This paper reports the results of a system-wide analysis of performance measures in use by CalTrans in the late 1970s. It identifies areas of strength and weakness of transit performance measures (TPMs) and discusses how they should be used.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: CalTrans, PennDOT, NYSDOT

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified:

- *Transit availability:* Reliability, connectivity
- *Service delivery:* Percent employment served, headway, percent transit-dependent served, percent population served, transit supply rate, connectivity
- *Service offered/utilization:* Transit utilization rate
- *Economics/productivity:* Cost per passenger, productivity, self-support ratio

Summary: This paper outlines some of the basic issues of TPMs. It distinguishes between efficiency measures (produced versus consumed resources) and effectiveness measures (how well the system meets its goals). It also outlines the following classifications for performance measures:

- Accessibility
- Convenience
- Travel time
- Comfort
- Safety
- Minimum cost to user
- Maintenance of environmental quality
- General public satisfaction

After briefly describing CalTrans' and PennDOT's experience with performance measure selection, the paper concludes that there are significant institutional, legal, and technological problems involved with the development of effective criteria. Specific problems were methodological and conceptual confusion as to the purpose of TPMs and what should be measured, as well as a lack of available data to evaluate the effectiveness of some TPMs.

Comments: This paper includes a large appendix with what appears to be all of the documents relevant to CalTrans' initial efforts towards creating a TPM program. These include initial letters of interest, initial proposals, design of the performance measures, and preliminary results from the system based on test implementations of the measures. While most of the data availability issues have been resolved by modern technology, the paper's main objection to TPMs is still valid. The limitations of TPMs should be given significant forethought before major policy and funding decisions are made based on their results.

Furth, Peter

"Data Analysis for Bus Planning and Monitoring"
TCRP Synthesis of Transit Practice 34
Transportation Research Board, Washington, D.C., 2000

Context: This TCRP synthesis addresses current industry trends in data gathering, storage, and methods of analysis.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☒ Applications of technology

Transit Systems Evaluated: This report surveyed 33 medium and large transit agencies in the U.S. and in Canada, in addition to conducting a review of other surveys in the literature.

Transit Modes Considered: Urban fixed-route bus, light rail

Service Contracting Addressed? No

Performance Measures Identified:

- *Service offered/utilization:* Passenger miles, trip length, unlinked trips, linked trips

Summary: This summary discusses the different methods used by transit systems to gather data on passenger counts, schedule adherence, and route and system performance. The report looks at methods of manual data gathering, such as operator trip cards, traffic checker data, and point check measurement by supervisors. Attention is given to the types of automatic data collection, including automatic vehicle location systems (AVL), automatic passenger counting systems (APC), and trip time analyzers.

The report found that methods of manual data gathering vary significantly between agencies, with significantly different levels of accuracy. Because of this, a great deal of data is lost or discarded as unusable, resulting in potentially inaccurate ridership and route performance measures. Automatic systems, while greatly increasing the statistical sample size available, still suffer from data accuracy problems. There is often a difference in automatic systems between real-time data gathering, which focuses on vehicle location for schedule adherence purposes, and off-line data gathering, which is more useful for system operation and management purposes. The report recommends that greater attention be given to integrating real-time monitoring with the recording of data for off-line analysis, so that both purposes can be satisfied.

The report concludes with the following findings:

- With proper attention, measurement error can be controlled.
- Automatic detection holds the key to performing statistically valid analyses of running time and route level schedule adherence.
- Operators should record location data for off-line analysis to support operational decision-making.
- Industry practice is not yet mature enough in its development of data systems for both planning and service-monitoring data.
- The industry is migrating towards general purpose database packages and away from specialized mainframe solutions.
- Network level and geographic analysis of ridership estimation are still in their infancy
- Commercially available data systems for transit operations may play a role in advancing industry practices.

Galíndez, Aníbel A., and Ricardo Mireles-Córdova

"Visualization of Transit Mobility and Performance"
Paper 99-1358, presented at the Transportation Research Board 78th Annual Meeting
Transportation Research Board, Washington, D.C., January 1999

Context: Development of a mobility model and a visual GIS platform to show how transit resources can be best utilized

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☒ Applications of technology

Transit Systems Evaluated: Los Angeles County MTA

Transit Modes Considered: All (bus in examples)

Service Contracting Addressed? No

Performance Measures Identified:

- *Service delivery:* Load ratio, average reliability (schedule deviation)
- *Service offered/utilization:* Mobility index
- *Economics/productivity:* Subsidy per boarding

Summary: The authors propose a mobility index and visualization process to represent the flow of people in a transit system. This mobility index is a measure of effectiveness defined as the product of average vehicle occupancy (AVO) and speed, expressed in units of passenger miles per vehicle hour. (The corresponding measure of efficiency is subsidy per boarding.) AVO is the product of average trip length and number of boardings, divided by vehicle miles.

The authors generate a graphic showing, for one route, load ratios and schedule reliability by time and location. The load ratio is AVO by time and location, expressed in the graphic as passengers per number of seats. Load ratio is classified as less than half of a seated load, one-half to a fully seated load, or a fully seated load. Schedule reliability is defined such that a transit vehicle is "early" if it arrives more than two minutes before the scheduled time, "late" if it arrives more than five minutes after the scheduled time, and "on time" otherwise.

The authors also promote the concept of a temporal geographic information system (GIS). A temporal GIS shows sequential snapshots of transit system characteristics, and it is useful for showing how service attributes (such as AVO) change with time. From such snapshots, patterns of attribute changes and the duration of such changes can be discerned. The authors apply this temporal GIS methodology to examples at the route, area, and region levels and claim that the methodology is applicable to most of the route evaluation standards identified in TCRP Synthesis 10, "Bus Route Evaluation Standards."

Comments: The authors claim that ride check data substitute adequately for real time data. TCRP Synthesis 3 discusses the shortcomings of ride check data.

It is assumed that, in their calculation of "average reliability," the authors mean the absolute difference between scheduled and actual arrival times at a time point, divided by the number of trips passing through that time point.

Gihring, Celine, and William Greene

"Washington State Ferries: Performance Measures and Information Support"
Transportation Research Record 1704, pp. 93-99
National Academy Press, Washington, D.C., 2000

Context: This paper documents Washington State Ferries' renovation of their old performance measurement system into one that directly relates performance measurement to managerial decision making and planning.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☒ Applications of technology

Transit Systems Evaluated: Washington State Ferries

Transit Modes Considered: Ferry

Service Contracting Addressed? No

Performance Measures Identified:

- *Comfort & convenience:* Customer satisfaction ratings on boat cleanliness, comfort, on-time performance, terminal access, parking, overall operations, and complaints
- *Service delivery:* Boat wait by route, travel time by route, transit connections by terminal, transit ridership by terminal, vessel utilization ratio by route
- *Economics/productivity:* Vessel operating cost per employee, terminal operating cost per employee, maintenance cost per employee, ratio of support to total employees, cost recovery ratio by route, cost per passenger transmitted, cost per vehicle transmitted, cost per trip, cost per passenger mile, cost per vessel mile

Summary: This paper is a general policy overview of Washington State Ferries' recent organizational changes with regards to performance measurement. It was written by managers at the Ferry system to demonstrate the organization's renewed dedication to using performance measures and information technology to enhance their customer service. It offers little actual reporting of specific numbers, details, or outcomes, and reads more like a PR document than an analytical report. It does, however, signal the system's intended shift from efficiency-based measures to effectiveness-based measures, even though such a shift has yet to occur. It also gives significant attention to their new information management procedures, which use "data warehousing" to coordinate the disparate legacy systems and reporting procedures that have impaired the organization's measurement and reporting efforts in the past. Unfortunately, this discussion offers little useful leads for other transit system managers as it remains entirely on the level of theory and avoids examination of specific methods or techniques.

Glauthier, Roy, and John Feren

"Evaluating Individual Transit Route Performance"
Transit Journal, pp. 9-26
APTA, Spring 1979

Context: This paper was written to help transit operators use performance measures to evaluate individual route performance.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Five systems were evaluated: The San Diego Transit Corporation, the North San Diego County Transit District, the Southern California Rapid Transit District, the Tri-County Metropolitan Transportation District of Oregon, and the Seattle Metro.

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? No

Performance Measures Identified:

- *Service delivery:* Operational standards
- *Service offered/utilization:* Average monthly revenue passengers, average monthly growth in revenue passengers, passengers per trip, passengers per bus hour, passengers per mile, revenue per mile, revenue per hour, cost per passenger, percent transfers

Summary: This paper is intended for system operators who want to use the performance measures model to evaluate individual routes within their system. It assumes the existence of a system-wide performance measures program and a working knowledge of common measures, such passengers per mile, revenue per mile, etc.

The authors emphasize the need for a strong relationship between system goals, service objectives, and operational standards. The general goals of the system (efficiency, speediness, maximum passengers, etc.) should define the service objectives, which are more specific, quantitative expressions of these goals. Service objectives in turn define which measures are to be used and what operational standards should be met.

In the case of the San Diego Transit Corporation, for example, the goal was "to operate as efficiently and economically as possible", which translated into specific objectives such as "increase system speed to as close to 15 miles per hour as possible", "decrease vehicle miles in revenue service by eliminating unproductive trips", etc. The service objectives in turn define the specific measures to be used and the standards that each route should meet. For instance, San Diego would choose vehicle miles in revenue service as a performance measure and set an operational standard of no more than 300 vehicle miles in revenue service per day. If a route measured higher than this standard, then operators would have a clear idea of which lines in the system were not meeting their overall system goals.

Glogowski, Leokadia, Thomas Schulze, Howard Mann, and Mark Tobin

Regional Transportation Statistics
New York Metropolitan Transportation Council (NYMTC), New York, NY, March, 2000

Context: New York Metropolitan Transportation Council (NYMTC) reports on the performance of the NY metropolitan region's transportation network. Transportation data and demographic information are gathered from various sources, analyzed, and reported by NYMTC staff. In the NYC region, the issue of regional performance is important because many commuters and travelers need to utilize more than one mode operated by more than one agency and cross different jurisdictions to get from their origin to their destination.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: NYC Transit, NJ Transit, MetroNorth, LIRR, PATH, NYC DOT contractors

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified: See the summary.

Summary: NYMTC publishes transportation and demographic statistics pertaining to the NY metropolitan region. By attempting to report performance on a regional basis, NYMTC supports intermodalism and seamless travel within the region's transportation network. By providing demographic as well as transportation data, NYMTC emphasizes the importance of demographics in influencing transportation movements. Some of the indicators and trends reported are: annual and weekday transit ridership on a regional basis along with agency-specific data; financial indicators such as operating revenues, passenger revenues, operating expenses, and deficits; equipment characteristics such as age of transit fleets; transit service performance indicators such as transit accidents; and demographic data such as employment, labor force population, unemployment, population, and housing units.

Comments: Because each agency has its own performance measures, definitions, data sampling, collection, and analysis methods may differ from one agency to another and make the aggregation of data or comparison of performance difficult. NYMTC addresses the problem by attempting to aggregate data to the extent possible.

Gorter, M.

"Implementing DOFT Quality Features in Public Transport Contracting"
Presented at the International Association of Public Transport (UITP) International Conference
UITP, Belgium, September 1999

Context: Conference presentation based on a research project sponsored by the German government

Applicability to G-6 Project:
- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None specifically

Transit Modes Considered: All

Service Contracting Addressed? Yes

Performance Measures Identified:
- *Community-based:* Ticket controls
- *Comfort & convenience:* Vehicle standards; station equipment; repair of damages; cleanliness of stations and vehicles; security; customer service.
- *Service delivery:* Personnel (number, outfit, qualification)
- *Vehicular capacity:* Train composition
- *Speed & delay:* Punctuality and connections

Summary: The main goal of the research project was to find ways to implement "soft" quality features in contracts. It is explained that in the contractual relationship between authorities and operators, the mutual obligations and the sanctions, in case the obligations are not fulfilled, must be detailed. Thus, performance, responsibilities, and sanctioning must be specified in contract relationships between public transport authorities and operators.

It is asserted that the present shift in many innovative transport companies from "systems thinking" to "customer thinking" must be transferred into contracting/tendering. This is claimed to be especially true for soft features of public transport, which influence customer perception of public transport, but for which quantitative indicators are hard to find.

It is reported that contract forms that contain revenue risks for the operators (net cost contracts) are an implicit incentive to raise quality. The drawbacks of this type of contract is that they cannot be applied everywhere, such as metropolitan areas with several operators.

Quality incentives in the tendering phase listed are:
- Monetary valuation of quality bids
- Requirements on implemented quality management systems as awarding criteria
- Staggering of tendering rounds

Quality incentives during operation listed are:
- Revenue risk
- Bonuses dependent on customer satisfaction
- Bonuses dependent on measurement of objective quality criteria
- Mutual liability of operators (e.g., regarding punctuality/connections)
- Participation of operators in success (e.g., revenues) of transport region
- Obligation to introduce a customer charter

Guttenplan, Martin, Bruce Landis, Linda Crider, and Doug McLeod

"Multi-modal Level of Service (LOS) Analysis at a Planning Level"
TRB Paper No. 01-3084
Transportation Research Board, Washington DC, 2001
http://www11.myflorida.com/planning/systems/sm/los/pdfs/MMLOASA_PlanLvl.pdf

Context: The paper presents methods of determining level of service for scheduled fixed-route bus users, pedestrians, and bicyclists that were developed in Florida for the Florida Department of Transportation (FDOT). These methods were developed to assist local governments in multi-modal transportation analysis.

Applicability to G-6 Project:
- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? No

Performance Measures Identified:
- *Transit availability:* Modified service frequency, span of service, pedestrian access

Summary: Florida's growth management law directed the FDOT to develop methods for multi-modal performance measurement and provide them to local governments. In considering multi-modal performance measures currently in use or developed elsewhere, for transit, the research found that the HCM 2000 methods evaluate the performance of the transit trip only but do not take into account access to the transit vehicle. The FDOT then developed a multi-modal level of service analyses to address congestion, the need to provide multi-modal choices and to make the best use of the State's transportation investment dollars. It should be noted that the paper discusses three modes - transit, pedestrian, and bicycle. This summary and review focuses on the transit mode.

Three levels of analysis, the generalized planning (look-up tables), conceptual planning (analysis which could require software but could use assumptions and/or default values), and operational planning (detailed analyses) are described. This paper concentrates on the conceptual planning level of analysis. Additionally, the transit system structure used in the research follows that in the *Transit Capacity and Quality of Service Manual* and the initial work focused on route segment analysis. The FDOT in a separate research project had developed a detailed operational planning level analysis application using GIS that incorporates bus frequency, span of service, and sidewalk connections within a field of residences and jobs (see Ryus et al.). The conceptual planning methodology presented in this paper combines the FDOT detailed operational planning application with the TCQSM methodology using simplifying planning assumptions. Key factors identified to affect a transit user's quality of service were: service frequency, pedestrian level of service, span of service, pedestrian crossing difficulty and sidewalk connections to the transit stop. The methodology for determining LOS for a transit user is presented through an example application. The methodology is based on a number of adjustment factors that are used to modify the service frequency of scheduled fixed-route bus service on a segment of roadway under evaluation. This modified service frequency is compared to the level of service thresholds in the TCQSM to determine the level of service experienced by a transit user in that segment.

The pedestrian level of service, which is an input to the bus segment level of service evaluation is computed separately. The presented bus LOS methodology is also dependant on several automobile mode inputs. The interdependencies created reflect the integration of modes in multi-modal analysis and could facilitate "what-if?" analyses. Separate modal outputs are produced so that the effects and results of any lesser-used mode is not masked. Possible applications of the methodologies developed are listed. Related research efforts by the FDOT are also presented in the paper.

Comments: For transit, the paper does not address comfort and convenience factors and focuses on availability. The pedestrian and bicycle LOS methodology presented addresses both availability of facilities and comfort of the user. The adjustment factors used in the transit methodology were not calibrated or validated through research.

Hartgen, David T.

Comparative Performance of Major US Transit Systems, 1998
University of North Carolina at Charlotte, August 8, 2000

Context: An annual report prepared by Professor Hartgen using data from the National Transit Database.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Results for 137 systems are reported.

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified:

- *Transit availability:* Population served per vehicle in maximum service, service area (square miles) per vehicles in maximum service
- *Service offered/utilization:* 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 1000 unlinked passenger trips, vehicle revenue miles per unlinked passenger trip, vehicle revenue minutes per unlinked passenger trip
- *Economics/productivity:* annual total revenue base per population, fare revenue per unlinked passenger trip, non-fare revenue as a percentage of total revenue, "performance index"

Summary: The author annually ranks major U.S. urban transit system in terms of economic performance, using data readily available in the National Transit Database. This report, the most recent available, covers 1998 performance, and compares performance for each year as far back as 1988. The 1998 report distributed by the author at the 2001 TRB Annual Meeting does not provide the methodology used; however, the abstract for the 1997 report does describe the methodology.

Rankings are based on a "performance index," which is based upon twelve performance measures. According to the author, five measures relate to resources (vehicles, population, fare revenue, non-fare revenue, and coverage area), while the other seven measures relate to results (operating costs per vehicle mile, vehicle hour, passenger trip, and passenger mile; population per rider; and vehicle revenue miles and minutes per trip). For each measure, a national average is calculated. 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. Next, 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.

Comments: Ten of the twelve measures are based entirely on economic performance. Systems that choose not to focus simply on serving their most productive routes, but also (for example) serving less-productive areas or times of day in order to satisfy broader agency and community goals, will suffer in the rankings as a result. 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, and another system that must serve an entire self-contained city, as well as other outlying areas. Other factors that vary between systems and which influence ridership and cost, such as poverty levels or cost of downtown parking, are also not considered.

The formula used to calculate the performance index is claimed by the author 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-New York City Transit ranked in the top three agencies for six of the twelve measures, and in the bottom four agencies for three of the twelve measures, and in between for the other three measures, yet ended up ranked 124th out of 137 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 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 particular action that agency management could take, and results in an overall poor ranking, it calls into question the validity of the comparison that is being made.

Finally, some of the measures in the index are auto-correlated, such as:

1. operating expense per revenue vehicle mile; and
2. revenue vehicle miles per unlinked passenger trips.

When the number of revenue vehicle miles goes down, the first ratio gets bigger (worse), while the second ratio gets smaller (better).

Hartman, R., E. Kurtz, and A. Winn

The Role of Performance Based Measures in Allocating Funding for Transit Operations
Transportation Research Board, Washington D.C., 1994

Context: A report on research sponsored by the Federal Transit Administration in cooperation with the Transit Development Board

Applicability to G-6 Project:
- ☒ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: A survey was conducted of 56 North American organizations (transportation departments and other funding agencies and operators); includes three detailed case studies (Pennsylvania, Indiana, and Texas)

Transit Modes Considered: All

Service Contracting Addressed? Yes

Performance Measures Identified: See the table in the Summary section for those used in the 1992 Florida transit performance evaluation, which are divided into performance indicators, effectiveness measures, and efficiency measures.
- *Service offered/utilization:* Vehicle miles (Pennsylvania); passengers (Indiana)
- *Economics/productivity:* Passenger revenue (Pennsylvania); operating expense and operating subsidy (Indiana)

Summary: This paper discusses the issues in the relationship between transit providers and the funding organizations, in particular the use of performance measures in determining funding levels. A survey was sent to 56 North American organizations, including state departments of transportation and transit operators, with a 45 percent response rate (12 funding agencies and 13 funding recipients returned). The paper gives three case studies on the funding allocation methods currently in use in state departments of transportation in Pennsylvania, Indiana, and Texas.

It is suggested that how to use performance information in a way that compares transit systems but that recognizes the vast difference among them with respect to geography, vehicle fleet, modes of service, population, land use and density characteristics, and even meteorological characteristics remains open to debate. Issues are reported to center on the ability of agencies to:

- Provide accurate definitions of good performance
- Establish appropriate sets of measurements and standards that accurately depict performance
- Compare transit organizations with vastly different characteristics
- Secure reliable financial data
- Accept the financial impacts that performance-based programs may yield
- Accommodate the intrusion of political concerns into the process

Performance measurement is defined as the assessment of an organization's output as a product of the management of its internal resources and the environment in which it operates. It is asserted that implicit in this concept is the notion that performance must be tracked against a standard, goal, or past performance, and a reward needs to serve as an incentive to move toward the desirable result.

The results from the survey showed that:

- Most respondents believed that it is very difficult, if not impossible, to make performance-based allocation work in the real world.
- No funding organization based its subsidy allocation completely on performance-related information. Two frequently used methods of funding allocation were a formula based on the populations and service area size or on a needs basis.
- Few funding organizations have set specific goals for assisting transit beyond the universal goals of mobility, economic development, and an improved environment. Goals that were most likely to be established for the performance measures are ridership, efficiency, local support, and service expansion.
- There exists a question on whether funding should go to the good providers as a reward or to the poor providers who may have greater financial need.
- State department of transportation managers admit the data they collect from funding recipients are unreliable.
- Different definitions and characteristics complicate the use of performance data.
- Politics often determines the funding recipients.

The primary funding allocation methods currently in use in state departments of transportation are:

- *Pennsylvania* – Formulas based on historical funding (financial need) and selected performance measures are used for the 38 fixed-route and demand-responsive transit systems. The two largest urban systems are funded based on achieving a set revenue to cost ratio (around 50 percent), while the other 19 urban systems have 25 percent of funding related to vehicle miles and 25 percent related to passenger revenue.
- *Indiana* – Formulas based on three performance measures (system passengers, operating expense, and operating subsidy) and the level of local funds contributed are used for the 32 transit systems.
- *Texas* – The funding to the 34 small urban and 41 rural transit systems is determined by system need and state affordability, after the previous method based on demographic and performance data was considered not to put the proper emphasis on improved performance and not promote partnership.

The final conclusions from the study were that:

- There continues to be a great diversity of opinion and approaches to the use of performance-based funding systems for public transportation by state and regional funding entities.
- There is a lack of clear-cut goals established for transit in many states.
- Some funding organizations find themselves struggling with the conflicts between their concerns for quality and quantity of transit service provided and the need to respond to legislative and taxpayer demands to constrain funding.
- There is widespread agreement among state departments of transportation and regional funding bodies that local transit system performance should be tracked. Fewer funding entities agree that the results should guide the financial subsidies, and fewer still are actually doing it.
- When performance components are used in subsidy allocation formulas, they tend to be combined with other non-performance factors.
- State departments that include performance measures in their funding calculations are using the measures as an incentive level rather than a determinant of base allocation, while other states are eliminating performance-based measures entirely.

Some state departments of transportation and planning organizations have considered performance measurement and performance-based allocation of funding; however, they recognize that developing appropriate and responsive measures and allocation mechanisms is not a small task.

The following summary of measures used in the 1992 Florida transit performance evaluation was reproduced from the report:

Summary of Performance Measures

Performance Indicators	Effectiveness Measures	Efficiency Measures
Service Area Population	Service Supply	Cost Efficiency
	Vehicle Miles per Capita	Operating Expense per Capita
Passenger Trips		Operating Exp per Peak Veh
Passenger Miles	Service Consumption	Operating Exp per Passenger Trip
	Passenger Trips per Capita	Operating Exp per Passenger Mile
Vehicle Miles	Passenger Trips per Rev Mile	Operating Exp per Rev Mile
Revenue Miles	Passenger Trips per Rev Hour	Operating Exp per Rev Hour
Vehicle Hours		Maint Exp per Operating Exp
Revenue Hours	Quality of Service	
Route Miles	Average Speed	Operating Ratios
	Average Age of Fleet (years)	Farebox Recovery
Total Operating Expense	Number of Incidents	Local Rev per Operating Exp
Total Operating Expense (1984 $)	Total Road Calls	Operating Rev per Operating Exp
Total Maintenance Expense	Rev Miles between Incidents	
Total Maintenance Expense (1984 $)	Rev Miles between Road Calls	Vehicle Utilization
Total Capital Expense		Vehicle Miles per Peak Vehicle
	Availability	Vehicle Hours per Peak Vehicle
Total Local Revenue	Rev Miles per Route Mile	Revenue Miles per Vehicle Mile
Operating Revenue		Revenue Miles per Total Vehicles
Passenger Fare Revenues		Revenue Hours per Total Vehicles
Total Employees		Labor Productivity
Transportation Operating Employees		Rev Hours per Employee
Maintenance Employees		Rev Hours per Operating Employee
Administrative Employees		Rev Hours per Maint Employee
		Rev Hours per Admin Employee
Vehicles Available for Max Service		Vehicle Miles per Maint Employee
Vehicles Operated in Max Service		Passenger Trips per Employee
Spare Ratio		Total Vehicles per Maint Employee
		Total Veh per Admin Employee
Total Gallons Consumed		
Kilowatt Hours of Propulsion Power		Energy Utilization
		Vehicle Miles per Gallon
		Vehicle Miles per Kilowatt Hour
		Fare
		Average Fare

Comments: The paper contains a good discussion of the issues in implementing performance-based measures and the current state of practice/opinion in North America.

Helfer, Bryna, Robert Carlson, and Sharon R. Smith

"How Mobility Planning Services Fits into an Overall Demand Management System"
Proceedings of the 2001 Bus and Paratransit Conference
American Public Transportation Association, Calgary, Alberta, 2001

Context: Describes the efforts of Easter Seals Project Action to develop a program in different communities that incorporates multiple elements into a demand management program designed to assist transit agencies in managing demand and assisting persons with disabilities in augmenting access and service quality

Applicability to G-6 Project:

- [x] Performance-measurement program description(s)
- [ ] Characteristics of effective performance measures or measurement systems
- [ ] Performance measure examples
- [ ] Market research
- [ ] Performance reporting
- [ ] Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: Urban fixed-route bus, urban demand-response (general public and specialized)

Service Contracting Addressed? No

Performance Measures Identified:

- *Community-based:* Consumer based service quality program
- *Transit availability:* Environmental barrier identification and reporting

Summary: This study is designed to develop an approach to managing service demand while maintaining access and quality, in order to meet the concerns of both the transit agency and persons with disabilities. The nine elements of the approach are:

- Functional eligibility assessments for ADA paratransit
- Consumer education for fixed-route usage
- Travel Buddy training for fixed routes
- One-on-one personalized professional travel training
- Driver awareness training
- Consumer-based fixed- route service quality reporting
- Consumer-based paratransit service quality reporting
- Environmental barriers identification and reporting
- Multi-modal trip planning

Three of the nine elements involve travel training, which is designed to transition as many individuals with disabilities as possible from paratransit to fixed-route services. Functional assessments are another demand management tool. Quality and performance of the services is consumer-based, not organizationally based, in this mobility planning services model. Environmental barriers identification and driver awareness are two more elements designed to meet consumer needs.

The balanced perspective of Mobility Planning Services, while not specifically designed for performance evaluation, represents some possible avenues of approach. It recognizes the importance of managing the demand on paratransit as a means of maximizing transit resources for persons with disabilities. Yet, it also emphasizes performance in areas that are important to persons with disabilities. That balanced approach will be essential in developing a comprehensive approach to paratransit performance evaluation.

Henderson, Gary, and Vengal Darapaneni

"Managerial Uses of Causal Models of Subway On-Time Performance"
Transportation Research Record 1451, pp.57-64
National Academy Press, Washington, D.C., 1994

Context: The authors, as part of research performed for the New York MTA inspector general's office, present a model that incorporates several factors that affect on-time performance (OTP) and can facilitate the comparison of subway routes that operate in different environments and conditions.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: MTA-NYC Transit

Transit Modes Considered: Heavy rail

Service Contracting Addressed? No (but there are implications)

Performance Measures Identified: None

Summary: The authors state that operating environments for different subway routes are so different that OTP cannot be compared unless specific factors are taken into account. They argue that some routes with low OTPs may be doing well, considering the operating environment, while some routes with high OTPs could do better. Their research demonstrated that the following variables had a significant impact on subway OTP:

- Number of route merges
- Whether public schools are in session
- Scheduled headway
- Distance traveled
- Stops
- Crowding
- Whether construction occurred the night before
- Mechanical reliability of subway cars

The research generated a causal model with which OTP could be predicted for a specific route. The authors recommend that, instead of measuring OTP "as is," predicted performance be compared against actual performance using this model.

Comments: The ideas have service contracting implications. If factors not under the control of the agency affect transit service, is it fair to penalize service providers for poor service? This question is a dilemma for service providers who wish to improve service for their customers but who also wish to be fair to their contractors.

Henderson, Gary, Heba Adkins, and Philip Kwong

"Subway Reliability and the Odds of Getting There on Time"
Transportation Research Record 1297
National Academy Press, Washington, D.C., 1991

Context: The authors, who work for the MTA inspector general's office, present a subway reliability indicator that reflects the customer's experience, using the concept of odds ratios.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: MTA-NYC Transit

Transit Modes Considered: Heavy rail

Service Contracting Addressed? No

Performance Measures Identified:

- *Community-based:* Customer-oriented reliability
- *Service delivery:* Reliability

Summary: The authors propose a new measure of on-time performance (OTP), which capitalizes on the concept of odds ratios. When odds ratios are applied to reliability measurement, the focus is on the number of days a passenger is on time versus the number of days a passenger is not on time. This is similar to the way in which customers actually think about reliability. The authors write that "on-time performance increases linearly, whereas the odds of being on time increase geometrically" and that the "odds of being on time are more in harmony with the concrete experience of riders." Because small changes in OTP have more of an impact on customers at higher levels of performance (e.g., an improvement from 95 percent to 98 percent means that the odds of being on time increase two-and-a-half times), they argue that the odds ratio better represents the customer's experience of OTP.

From the operational viewpoint, because an upper boundary of 100 percent gives transit managers the impression that transit service reliability cannot be improved, the authors advocate the use of a logit model. *(This contradicts the 0-to-1 scale recommended in the "Regularity Indices for Evaluating Transit Performance" paper.)*

Comments: The odds ratio concept has merit in that it represents the way customers view their transit experience. The concept is more applicable to commuters than to infrequent riders.

Henderson, Gary, Heba Adkins, and Philip Kwong

"Toward a Passenger-Oriented Model of Subway Performance"
Transportation Research Record 1266
National Academy Press, Washington, D.C., 1990

Context: The authors, as part of the MTA inspector general's effort to measure NYC Transit's subway service from the customer's perspective, presents a passenger-oriented indicator of subway performance. At the time the article was written, there were no customer-oriented measures of subway performance at NYC Transit.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: MTA-NYC Transit

Transit Modes Considered: Heavy rail

Service Contracting Addressed? No

Performance Measures Identified:

- *Community-based:* Customer-oriented reliability
- *Service delivery:* Reliability

Summary: The authors propose a customer-oriented model of on-time performance (OTP) measurement for New York City subway service. They assert that a customer-oriented model should focus on:

- Percentage of passengers arriving on time, not on the percentage of trains arriving on time
- Definition of delay that is customer-oriented – For example, when a train breaks down, delay should be calculated as the difference between the time when a particular train breaks down and the time when the next train arrives (not when the train has been taken out of service).
- Performance at en route locations, not terminals – For most subway lines, significant boarding and alighting activity occurs at en route locations, not terminals; hence, it makes sense to focus on the former, not the latter.
- Peak directions – In the morning rush, performance of CBD-bound trains should be given more weight, due to the large number of riders going in this peak direction.

The performance models proposed by the authors measure service from the customer's point of view, while preserving the capability to produce operational measures. The following are described: standard OTP, passenger-weighted OTP, operational OTP, total-trip OTP, and weighted total-trip OTP.

Comments: Note that the customer-oriented bus performance indicator program at MTA-NYC Transit incorporated some of the concepts articulated by the MTA Inspector General's office.

Henderson, Gary, Philip Kwong, and Heba Adkins

"Regularity Indices for Evaluating Transit Performance"
Transportation Research Record 1297
National Academy Press, Washington, D.C., 1991

Context: The MTA inspector general's office researched methods to measure the evenness of bus service as no such method existed at the time. This paper presents two methods that resulted from the research.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: MTA-NYC Transit

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? No

Performance Measures Identified:

- *Community-based:* Customer-oriented reliability
- *Service delivery:* Reliability

Summary: The authors propose the headway regularity index and passenger wait index for high-frequency transit services.

The following characteristics of the regularity index make it suitable for evaluating transit performance:

1. Transfers – Supervisory actions, such as holding back buses or turning them short, if successful, will redistribute headways and increase the value of the index. This process is useful in testing the effectiveness of road supervision.
2. Scale Independence – Proportional addition or subtraction to all headways leaves the index unchanged. Schedule changes that increase or decrease the scheduled headways will not affect the index except insofar as the changes improve or worsen service regularity.
3. Normalization – The scale ranges from 0 to 1. All routes are calibrated to the same scale, making comparison possible.
4. Operationality – Because the index is straightforward, unambiguous, and objective, different researchers with potentially different subjective interests will still produce the same measure of regularity.

With regard to the passenger wait index, the authors note that existing wait time measures apply only to frequent service when customers arrive randomly at the bus stop. When headways are longer, customers tend to time their arrivals, and, hence, another way to measure wait time is needed. The authors mention that wait time is also a function of service regularity—as service regularity diminishes, wait time increases.

The authors note that "psychological dimensions" of customers should be considered for customer-oriented measures but not for operational measures. For example, if studies proved that each additional minute of delay causes a disproportional decrease in satisfaction, then this should be captured in customer-oriented measures. Also, both indicators control for the mean headway, permitting the comparison of different routes, and are expressed on a normalized scale (0 to 1).

Henk, Russell H., Sarah M. Hubbard, Timothy J. Lomax, and Gordon A. Shunk

Developing Transit Availability Measures and an Index of Transit Service Availability
Report No. SWUTC/95/60028-1
Southwest Region University Transportation Center, College Station, TX, July 1995

Context: This paper describes the development of an index of transit service availability (ITSA) for planning applications.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: The ITSA was applied to 228 urban systems in the U.S.

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified: (These are the primary "issues" for which over 30 quantitative measures were considered. See the summary for more information.)

- *Transit availability:* Overall transit service availability (defined to include transit service coverage, frequency of transit service, and transit service capacity)
- *Service offered/utilization:* Transit system utilization; directness of transit service

Summary: The authors write that the ITSA is a planning tool that can be used to "assess the adequacy (and more specifically, availability) of public transit in urban areas." The ITSA allows assessment of transit availability over time as well as comparison of transit availability in urban areas with similar populations and population densities. The ITSA is "not intended for use in assessing transit system efficiency and/or performance."

The authors considered five components of transit service availability:

- Transit service coverage – "the spatial proximity of transit service to both the origin and destination of a trip" or "the transit density of relative coverage of transit service"
- Frequency of transit service – "the total hours of daily transit operation and the frequency with which this service is provided (headways between transit vehicles)"
- Transit service capacity – during the peak periods
- Transit system utilization
- Directness of transit service

Only the first three components were included in the ITSA. (Transit system utilization and directness of service were concluded to primarily measure performance rather than availability.) Quantitative measures based on FTA Section 15 (National Transit Database) data were then identified for each component (from over 30 possible quantitative measures, which are defined in the appendix to the paper):

- For transit service coverage, the authors used directional route-miles per square mile.
- For frequency of transit service, the authors used vehicle-miles per directional route-mile.
- For transit system capacity, the authors used seat-miles per capita.

Note that each measure is a transit system characteristic divided by a demographic characteristic.

These measures were selected from among other possible measures because they are the least correlated with each other. A logic check also was performed to verify the reasonableness of the selected measures. In this logic check, 20 urban areas covering a range of populations and population densities were ranked by the project's advisory committee according to "perceived transit service availability." The perceived ranking was then compared to rankings ordered by each of the selected measures.

Once the three quantitative measures were identified, 228 U.S. urban areas were stratified by population and by population density. The three measures were calculated and normalized for each urban area within the stratifications. The ITSA was then calculated as the unweighted average of the coverage, frequency, and capacity measures. The results for all 228 urban areas are reported in the paper. ITSA values were found to vary between urban areas "as expected."

The limitations of the ITSA are:

- It is based on demographic data for an urban area, not a transit service area.
- It includes all transit agencies providing service in a given area, so the results may not be useful to a specific agency.
- The FTA Section 15 (now National Transit Database) source data are "perceived to be somewhat questionable with regard to total reliability."

Comments: The authors' logic check is an excellent technique because it is practical and quick. The ITSA components are unweighted because the authors found no "justifiable method for doing so."

It is important to emphasize that, as the authors state, the ITSA measure is a planning measure; it is not intended as a basis for making operational decisions. Measures of performance and utilization were intentionally excluded from ITSA calculation.

Note that the definition of transit service frequency includes both hours of service and headways.

As noted in the summary section, the authors identified over 30 quantitative measures that could be included in the ITSA. These are classified and defined in the appendix to the paper.

Hill, Mary C.

Performance Measures for California Transportation System Users and Investors Conference Summary
Sacramento, CA, October 6-7, 1997

Context: This conference on performance measures was held to learn about developing and implementing transportation performance measures and to help CalTrans develop a set of intermodal system-level transportation performance indicators.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified: None

Summary: This conference on performance measures was held to "build a common frame of knowledge and language for addressing the process of discovering, developing, and implementing a transportation performance measure system for California; to learn firsthand about experience with the process of developing and implementing transportation performance measures at the national, state, and regional levels from experts in the field; to understand how performance measures can improve policy formulation and decision making in the complex, politically-charged world of transportation resource allocation; and to help CalTrans develop a set of intermodal system-level transportation performance indicators that will become a part of the ongoing planning, management, and policy making process for transportation in California."

The Governmental Performance and Results Act of 1993 was intended to link federal agency goals with outcome-based performance measures (PMs) and required DOT to come up with performance measures to assess progress toward its transportation goals. With this in mind, several uses of PMs were discussed at the conference. These are:

- Program performance, evaluation, and accountability
- System performance
- System planning
- Budget prioritization
- Triggering device
- Improving customer choice

Speakers from diverse geographic areas provided examples of the use of PMs by states and MPOs:

- Texas uses PMs for all budgeting and allocation purposes. In 1993, Texas instituted a strategy-based budget and a complex system of PMs. Currently, it has more than 10,000 PMs.
- Minnesota has a comprehensive set of measures adopted in 1993 as well, for the purpose of internal management, system monitoring, evaluation of customer satisfaction, and justification of investment funding decisions.
- Florida initiated PMs in 1990 and a performance-based budgeting program in 1995.

- Oregon, Virginia, and North Carolina were also mentioned, as well as Capital District Transportation Committee (CDTC) of Albany, NY, Southern California Association of Governments, and the Metropolitan Transportation Commission of the Bay area at regional levels.

Points made during the conference include:

- Speakers noted that outcomes should be measured rather than outputs. Michael Meyer stressed the importance of demonstrating the causal links between PMs and the desired outcomes (goals).
- PMs should be used as decision tools, not rules.
- Martin Wachs said that PMs do not replace politics but may "help to reassert a balance between political decision making and scientific and technical knowledge."
- Process should be emphasized, not just the product. The required consensus building process among various stakeholders proved to be invaluable to many states that had developed PMs.
- Political "buy-in" is an important element for the success of PMs. Without it, PMs may be ignored or misused.
- Including the customer is essential. It is important to categorize user expectations by mode/route/location, etc. PMs must account for the many factors that differentiate users and travel characteristics.
- The need for simplicity, yet comprehensiveness, and the tradeoff dilemma was noted.
- John Poorman of CDTC stated that PMs should not be data driven—specific subjects should be left open if no data is readily available at a particular time. However, others believed that cost, availability, and timeliness of the data for a specific PM should be weighted against the importance of the PM.

Hodge, David C., and James D. Orrell, III

Measuring Level of Service and Performance in Public Transportation
Washington State Transportation Center, Washington State DOT, Seattle, Washington, November 1995

Context: Washington State DOT research on conceptually clarifying legislative mandates and developing of evaluation criteria for each mandate.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Four case studies in the state of Washington are presented.

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified: Only examples—see the summary.

Summary: The purpose of the research described in the article was to provide conceptual clarification to legislative mandates and develop evaluation criteria in meeting these criteria. The specific objectives are "the development of a framework to categorize the inter-relationships among the concepts found in the new legislative environment" and "the development of a framework to organize and interpret a wide range of potential performance and level-of-service criteria that are potentially useful in assessing the success of public transportation in meeting its legislative mandates and expectations." Other objectives of the research involved the "exploration of specific applications of evaluation processes and criteria for different legislative mandates," "exploration of the use of evaluation criteria specifically associated with state-level planning goals," and the "exploration of the relationships between typical public transportation performance measures and geographic context variables." Four case studies (Olympic Peninsula, King County cities, Puget Sound region, and accessibility for the residents of Washington State) are provided in the report. Many of the ideas provided by the authors are from the perspective of WSDOT.

The portion of the report dealing with the application of performance evaluation criteria pertains to transit performance measurement. The research objectives included exploring specific applications of evaluation processes and criteria for different legislative mandates, exploring the use of evaluation criteria specifically associated with state-level planning goals, and exploring the relationships between typical public transportation performance measures (PMs) and geographic context variables. Figure 1 in the report shows the framework used by the authors to represent the basic elements of transportation provision and evaluation. In the framework, outcomes, rather than outputs, are emphasized and are linked to goals driving the process.

Measures may "ultimately reflect a specific, institutional, political, or social perspective towards public transportation, and, when entities choose certain measures over others, public transportation provision and evaluation are directed towards certain results, whether that is intended or not."

Recommendations that came out of the study include the following:

- No single PM should be used to evaluate any system, service, or policy.
- However, in reality, many agencies do focus on only one criterion.
- For Washington:
  - Local authorities and communities are in the best position to lead the PM selection.
  - The State role should be to facilitate the evaluation process.
  - Minimum standards of access for all residents should be established.

Horowitz, Alan J., and Nick A. Thompson

"Generic Objectives for Evaluation of Intermodal Passenger Transfer Facilities"
Transportation Research Record 1503
National Academy Press, Washington, D.C., 1995

Context: This article focuses on the evaluation of project alternatives for intermodal passenger transfer facilities; the main theme of the article revolves around the list of 70 generic objectives which were rated by planners.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified: See the summary.

Summary: The criteria for selecting projects for intermodal passenger facilities were created by consulting experts on planning, design, and operation of passenger transfer facilities. Objectives were classified into four general objectives: (1) mode interface objectives, (2) internal objectives, (3) system objectives, and (4) external objectives. The objectives were also placed in the following categories: transfer, safety/security, access, efficiency, passenger, financial, modal enhancement, physical enhancement, nonphysical enhancement, space/site, architectural/building, and coordination. The top ten objectives were:

- maximize reliability of transfers;
- maximize security, maximize safety and security of operations of modes;
- minimize institutional barriers to transferring, maximize passenger information;
- achieve handicapped access;
- maximize safety;
- maximize user benefits;
- maximize reliability of facility services; and
- maximize system legibility.

According to the authors, the following are features of a good evaluation of alternatives for project selection. A good evaluation should:

- Be capable of generating and evaluating alternatives
- Incorporate available expertise, including knowledge of modal operations
- Foster the establishment of goals, objectives, and criteria for the project
- Have sufficient staff support to accomplish necessary data collection, analyses, and reporting
- Contain mechanisms for fast and clear communication among the many participants in the process
- Have the ability and authority to choose an alternative
- Have a process consistent with the style of planning that exists within the local community
- Have one or more individuals responsible for setting goals and translating them into objectives

Hsiao, Shirley, Jian Lu, James Sterling, and Matthew Weatherford

"Using GIS for Transit Pedestrian Access"
Presented at the 76th Annual Meeting of the Transportation Research Board
Transportation Research Board, Washington, D.C., January 1997

Context: This paper describes how the Orange County Transportation Authority (OCTA) evaluated system-wide pedestrian accessibility using GIS to "link ridership with land use and demographic characteristics at a detailed local level."

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☒ Applications of technology
- ☒ Other: Measurement technique

Transit Systems Evaluated: Orange County (pedestrian access to transit only)

Transit Modes Considered: All bus stops

Service Contracting Addressed? No

Performance Measures Identified:

- *Transit availability:* Pedestrian access to transit (coverage area)

Summary: The paper describes a "conceptual framework" intended to "provide an analytical tool which combines a transit-oriented development theory with empirical data analysis so transit planners can better measure pedestrian access at the local level." The authors identify three questions to be answered in development of this framework:

- How do you measure pedestrian access to transit?
- How do you evaluate the impact of street configuration on pedestrian access?
- Will people use transit if it is within walking distance of their origin and destination?

The following databases are necessary in the authors' framework:

- Street network database
- Bus stop database
- 1990 Census data
- 1990 Census Transportation Planning Package (TPP) journey-to-work transit trip database
- Countywide employment database
- Land use database

Walk trips were not allowed to travel along freeways, bridges, and railroads. Bus stops were associated with the nearest intersection in most cases. Transit work trips were used as the "ridership indicator." From survey data, the authors defined the "catchment area" of a bus stop points reachable within one-quarter mile walk distance from the bus stop. The "transit buffer area" is defined as the area within one-quarter mile air distance from the bus stop. The difference between the buffer area and the catchment area is the "potential for access improvement."

Three “case studies” were conducted using GIS:

- *Pedestrian Access Characteristics and Street Configuration* – The authors found that grid streets and higher densities have higher pedestrian access.
- *Pedestrian access and Mode Choice* – The authors asked if people use transit more when they live and work within walking distance of transit. They found a “strong relationship between bus ridership and pedestrian access,” especially in lower-income neighborhoods.
- *Pedestrian Access for Existing and Proposed Bus Systems* – The authors found that restructuring routes resulted in 2.0 percent more residents and 1.6 percent more jobs within walking distance of transit.

Comments: The authors’ findings are theoretical. One nice—and very important—feature of the authors’ methodology is that pedestrian access to transit at *both* ends of a given trip is included.

Regarding the second case study, the finding that lower-income neighborhoods show a stronger relationship between bus ridership and pedestrian access suggests that other aspects of transit service may be discouraging residents of higher-income neighborhoods from using transit, regardless of the level of pedestrian accessibility in the higher-income neighborhoods. A study of actual pedestrian access and ridership may offer insights on this observation.

The third case study shows that the authors’ framework is independent of hours and frequency of service; pedestrian access to transit is entirely a coverage area measure. More residents and jobs were “accessible” with the restructured routes, but the restructured routes were accompanied by a five percent decrease in overall service hours that is not reflected in “accessibility.” In this case study, though, the agency was able to achieve cost savings (fewer service hours) and higher ridership.

Iannuzzielo, Angela Stern, and Dennis A. Kar

"Customer Focused Design for a Small Sized Transit System in Eastern Ontario"
Proceedings of the 2001 Bus and Paratransit Conference
American Public Transportation Association, Calgary, Alberta, 2001

Context: A consultant was hired by the City of Cornwall to perform a comprehensive review of Cornwall Transit, the local transit agency. For its service review, the consultant used a market-based service approach.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☒ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Cornwall Transit

Transit Modes Considered: Urban fixed-route bus, urban demand-response (specialized)

Service Contracting Addressed? No

Performance Measures Identified:

- *Comfort & convenience:* Uses market based service design with the primary principle that successful transit should directly and conveniently take passengers where they want to go

Summary: The consultant was retained by Cornwall Transit to (1) perform a service review and design transit services that would focus on improving service from the perspective of the customer and (2) design a strategy to address improvements and address service effectiveness based upon that objective. This paper describes the consultant's service review, which was geared towards accommodating the needs of three specific market segments as a method of increasing the overall ridership of the transit system: students, industrial employees, and seniors. The consultants based their service design concepts on a set of principles general enough to be applied broadly across an entire transit system that included a variety of services (including transit services for the elderly and disabled) yet specific enough to attach an action to each that contributed to the fulfillment of the overall service design goals. Cornwall Transit wanted to focus both on capturing underserved riders and on providing better service to existing riders.

Comments: The principles behind the consultant's service design concepts provide a different view of a "successful" transit system beyond the traditional performance measures that measure service effectiveness based on passengers per trip/per hour, etc. For example, the consultant defined the market to be addressed in its service design/improvement, assigns common trip origins, destinations and attractors, and generators for that market, and measures performance on the principle that a successful transit service for say, the elderly, should include routes to homes for the aged.

Interactive Elements, Inc.

Safety Review of Washington Metropolitan Area Transit Authority (WMATA) Metrorail Operations
Federal Transit Administration Report DOT-FTA-MA-90-9005-97-1
Volpe National Transportation Systems Center, Cambridge, MA, September 1997
http://transit-safety.volpe.dot.gov/Publications/Safety/WMATA/wmata.pdf

Context: Review of safety and operational issues at WMATA following a series of incidents in 1996.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: WMATA (Washington, DC)

Transit Modes Considered: Heavy rail

Service Contracting Addressed? No

Performance Measures Identified:

- *Service delivery:* On-time performance, headway regularity, passenger off-loads
- *Safety:* Station overruns

Summary: This report takes an in-depth look at problems with WMATA's Metrorail operations that contributed to a series of incidents in 1996, including a fatal accident in icy conditions in non-revenue service, a delayed response to a fire, problems with tower supervisor directions in yards, two workers injured when their tools made contact with a live electrical cable, and disconnected operating mechanisms on mid-car emergency doors. The report is reviewed from the perspective of how effective performance measurement can contribute to better safety.

The report begins by stating that most transit agencies commonly state safety as a primary goal, and that safety should encompass all aspects of a transit system's functions. At WMATA, the role of the safety program was downgraded over time, through internal reorganizations, staff and budget reductions, and de-emphasis of safety in public and internal communications. In particular, safety reporting was originally made to the general manager, but reporting fell further down the chain of command (to different deputy general managers and the risk management office) as internal reorganizations occurred.

Some shortcomings in the safety program that were identified included the following that related to performance measurement:

- No trend analysis of accident statistics
- No tracking of costs of accidents
- No guidance of safety training
- No defined hazard identification and resolution process

The report faulted the way several performance measures were used. The fact that WMATA tracked headway regularity rather than on-time performance "as an indicator of system health. On-time performance is a nearly universal indicator of overall rail transit system health. In its place, WMATA has traditionally utilized headways (the interval of time between trains), which, while sound for bus systems where 'bunching' is an issue, fails to account for deterioration in running speed and other potential problems on rail systems.

Station overruns (where the front of a train stops 36 inches or more past the end of the platform) were tracked, but not considered to be a safety issue. WMATA averaged 450 overruns a year, compared to 15-20 a year for BART. For manually operated systems, station overruns are said to be a cause for immediate investigation and possible operator relief. For automated systems, such as WMATA, they are an indication that design assumptions are not being met, either in terms of braking rates during inclement weather or the reliability of the automated systems that control station approaches. In either case, failure for a train to stop where designed to could have serious consequences in an emergency braking situation.

Passenger off-loads (where a train breaks down, passengers are taken off at a station, and the train moved to a maintenance facility) were also tracked and reported to the WMATA Board, but “little or no effort” was made to correct why the off-loads occur.

Comments: The report highlights the use of performance measures as indicators of potential safety problems, before a serious incident occurs. It also makes clear that tracking and reporting measures does no good unless actions are taken to correct the problems that the measures identify.

Kaplan, Robert S., and David P. Norton

"The Balanced Scorecard—Measures that Drive Performance"
Harvard Business Review on Measuring Corporate Performance
President and Fellows of Harvard College, Cambridge, 1998

Context: The authors describe the uses and benefits of a "Balanced Scorecard" measurement system.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: None

Service Contracting Addressed? No

Performance Measures Identified: None

Summary: Kaplan and Norton developed the Balanced Scorecard, a set of measures that includes financial measures that express past performance, and measures of customer satisfaction and innovation that drive future performance of an organization. The Balanced Scorecard is described as a comprehensive tool that allows senior executives to get a complete picture of performance without having to review hundreds of performance indicators. They argue that "managers should not have to choose between financial and operational measures" and that "the complexity of managing an organization today requires that managers be able to view performance in several areas simultaneously." Hence, suboptimization is avoided. If improvement in one aspect of the organization diminishes the performance in another, the scorecard will show it.

The customer perspective: Customer goals should be identified and then translated into measures. Instead of relying on measures that the management thought customers wanted, they asked the customers to describe what type of product and service they wanted and what various service attributes such as "reliability" meant to them. Because some customers said they considered delivery within 5 *minutes* to be on time and the company was using a different definition, the company adjusted its definition to meet the expectations of its top ten customers.

The internal business perspective: To meet customer needs and expectations, managers need to focus on critical operations that lead to services and products that customers desire. The internal measures should be ones that contribute the most to customer satisfaction. These internal measures may be worthless if an organization does not have a responsive information system. For instance, if a measure for on-time performance is poor, an organization with a good information system will be able to readily pinpoint the cause of the problem, while organizations with unresponsive systems will be unable to do so.
The authors believe that the difference between the Balanced Scorecard and traditional performance measurement methods is that the Scorecard stresses vision and strategy rather than control. Traditional measurement systems specified the actions that employees should take and then evaluated them using the measures. The scorecard sets goals and objectives but leaves it to the employee to determine the best course of action to achieve them. (*This idea can be applied to the performance measurement systems we envision for transit agencies. Many of the agencies will have similar goals and objectives, though each agency may take a different approach on achieving them.*)

Comments: The target audience for this article is not public agencies. However, many of the concepts regarding performance measurement could be applied to the public sector (e.g., transit agencies).

Kaplan, Robert S., and David P. Norton

"Putting the Balanced Scorecard to Work"
Harvard Business Review on Measuring Corporate Performance
President and Fellows of Harvard College, Cambridge, 1998

Context: The article describes organizations that have put the Balanced Scorecard into practice and presents their experiences and lessons learned.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: None

Service Contracting Addressed? No

Performance Measures Identified:

Summary: Four case studies of companies that have implemented the Balanced Scorecard are presented in this article.

Rockwater is a leader in underwater engineering and construction. The vision established by the senior management focused on being the industry leader. Strategies that came out of this vision were:

- Services that surpass needs
- Customer satisfaction
- Continuous improvement
- Quality of employees
- Shareholder expectations

The four categories of performance measures (PMs) that were developed based on these strategies include:

- Financial
  - Return on capital
  - Cash flow
  - Project profitability
  - Reliability of performance
- Customer
  - Value for money
  - Competitive price
  - Hassle-free relationship
  - High-performance professionals
  - Innovation
- Internal
  - Shape customer requirement
  - Tender effectiveness
  - Quality service
  - Safety/loss control
  - Superior project management

- Growth
    - Continuous improvement
    - Product and service innovation
    - Empowered work force

Other case studies included in this article are Apple Computer, Advanced Micro Devices, and FMC Corporation. The typical steps that can be taken to implement the Balanced Scorecard are as follows:

1. Preparation – Define the business unit for which a scorecard is appropriate. The unit should have its own customers, distribution channels, production facilities, and financial measures.
2. Interviews – The facilitator interviews senior managers and principal shareholders to obtain input on strategic objectives and possible measures.
3. Executive Workshop – Senior managers are brought in and asked to debate the mission and strategy statements until a consensus is reached. A draft scorecard is then established.
4. Interviews – The facilitator will document the output from the workshop and obtain opinion from individual senior managers.
5. Executive Workshop – Two more workshops are conducted to fine-tune the scorecard.
6. Implementation – A team develops an implementation plan for the scorecard.
7. Periodic reviews – The scorecard would be reexamined on an annual basis

Comments: The target audience for this article is not public agencies. Some of the lessons learned from case studies could be applied to the public sector (e.g., transit agencies).

Kaplan, Robert S., and David P. Norton

"Using the Balanced Scorecard as a Strategic Management System"
Harvard Business Review on Measuring Corporate Performance
President and Fellows of Harvard College, Cambridge, 1998

Context: A strategic management system was developed by several companies after the implementation of the Balanced Scorecard. The system and its components are described in the article.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: None

Service Contracting Addressed? No

Performance Measures Identified: None

Summary: Organizations are using the Balanced Scorecard method as "the cornerstone of a new strategic management system." Organizations began using the Balanced Scorecard without such a system; however, by constructing the scorecard, cataclysmic change processes occurred in many of the companies. The authors describe the strategic management system created in these companies as consisting of the following:

1. Translating the vision – building a consensus around the organization's vision and strategy
2. Communicating and linking – managers communicate their strategies vertically and link it to departmental and individual objectives
3. Business planning – helps companies integrate their business and financial plans
4. Feedback and learning – provides managers with capacity for strategic learning

The authors provide a step-by-step description of how a company built a strategic management system. The final step links every employee's performance to the Balanced Scorecard.

Comments: The target audience for this article is not public agencies. However, a few of the concepts might be applied to the public sector (e.g., transit agencies).

Karlaftis, M.G., and P.S. McCarthy

"Subsidy and Public Transit Performance–A Factor Analysis Approach"
Transportation, 24(3), pp. 253-270
Kluwer Academic Publishers, August 1997

Context: Journal article

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Eleven fixed-route and fixed-schedule operators in Indiana

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? Yes

Performance Measures Identified: An integrated factor analysis model is developed using certain measures, as shown in the figure in the Summary section.

Summary: The factor analysis method is used to generate a set of underlying attributes that "best" describe the performance of public transit systems. The paper generates factors to measure efficiency, effectiveness, and an overall value. It was found that subsidies have generally exerted a negative influence on the performance and productivity of transit systems.

Comments: There is a strong similarity between the indicators in the paper and those selected in previous 1985 research, with the conclusion that the most important determinants of the performance of transit systems have remained relatively unchanged over time and across systems.

Kasoff, Mark J.

"The Quality of Service and Transit Use"
Traffic Quarterly, Volume 24, pp. 107-119
Eno Transportation Foundation, Inc., Lansdowne, VA, 1970

Context: This paper presents the results of the author's study of the relationship between transit ridership and quality of transit service.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Thirteen medium-sized cities in the Midwestern U.S., with a case study focus on Fort Wayne, Indiana

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? No

Performance Measures Identified:

- *Transit availability:* Information offered, route-miles, route-miles per capita, headway, ratio of route miles to street miles
- *Comfort & convenience:* Mean vehicle age, fares, fare collection procedures
- *Service delivery:* Accessibility to origins and destinations, frequency of service, reliability (frequency of breakdowns and delay due to breakdowns)
- *Service offered/utilization:* Number of vehicle miles traveled per year, number of vehicle hours traveled
- *Speed & delay:* Mean operating speed; ratio of bus to automobile operating speeds

Summary: The research presented in this paper is "an attempt to discover whether or not a relationship exists between the quality of transit service and the level of transit patronage." The author states that the difficulties in discovering this relate to a lack of readily available data on the quality of service variables and a lack of knowledge of the characteristics of riders (i.e., unknown utility functions).

The author focused his research on transit system data from 13 medium-sized cities in the Midwestern U.S. To measure the effects of factors such as new equipment, extension of route operations, and increases in speeds, these data included the following quality of service variables:

- Route miles – This is defined as "the number of route miles in a city exclusive of trip frequency." Ridership is expected to increase with route miles.
- Route miles per capita – This variable adjusts the route miles measure to account for population differences between the cities included in the author's study.
- Headway – This is defined as "the [peak hour] frequency of service along a route." (Note that headway is actually the inverse of frequency.) Ridership is expected to decrease as headway is increased.
- Mean vehicle age – This variable represents vehicle comfort and reliability. Ridership is expected to decrease with increases in mean vehicle age.
- Fares – It is expected that, as fares increase, ridership declines.

The author first developed five simple linear regression models to represent the effects of the above variables on transit use. Each of the models included only one independent variable. Results were generally "weak," and the author concluded that "no single factor appears to affect patronage appreciably." The author then developed a set of multiple linear regression models in which the collective effects of the transit service variables were evaluated. The results of this were "much more encouraging."

The results of the case study of Fort Wayne, Indiana, were similar. The following quality of service variables were used in the case study:

- Number of vehicle miles traveled per year (found to be significant individually)
- Number of vehicle hours traveled (found to be significant individually)
- Mean operating speed (not found to be significant individually – the author suggests that a ratio of bus to automobile speeds would be better)
- Ratio of route miles to street miles (not found to be significant individually)

The author concluded that a single performance measure is inadequate in explaining changes in transit ridership. Several performance measures, collectively, perform better. This is borne out by statistical analysis of the 13 cities and by the experiences in individual cities.

Comments: Between the study of the 13 cities and the Fort Wayne case study, the author's selected variables shift from measures of availability and comfort/convenience to measures of utilization and speed/delay.

Though this paper was written in 1970, the majority of it is relevant to the TCRP G-6 research. One exception to this is that the paper appears to have been written before monthly transit passes and similar fare collection innovations became widespread. Hence, "fare collection procedures," as the author intends it, may be a dated performance measure.

The author begins the paper with a warning about (and an example of) the difficulty of distinguishing between influences on the demand for service and influences on the supply of service. This should be considered in the evaluation of performance measures identified or developed in the TCRP G-6 research, particularly paratransit performance measures. The author also emphasizes the importance of measuring the quality of alternatives to urban transit. He writes that "travel decisions are made in a relative world." This suggests that an effective transit performance measurement system might include comparisons to alternative travel modes.

Ketola, H.N., and D. Chia

"Developing Useful Transit-Related Crime and Incident Data"
TCRP Web Document 18 (Project F-6A): Contractor's Final Report
Transportation Research Board, Washington, D.C., April 2000
http://nationalacademies.org/trb/publications/tcrp/tcrp_webdoc_18.pdf

Context: Final report of FTA-sponsored research on transit security

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology
- ☒ Other: Research on transit security

Transit Systems Evaluated: Surveys of MARTA, MBTA, PATCO, GCRTA, Houston MTA, NJ Transit, MCTO, LIRR, NY Metro North, BART, Amtrak, SEPTA, PAT, WMATA, LACMTA, Miami-Dade TA, Milwaukee County Transit, AC Transit, Phoenix Transit, Utah Transit Authority, Bi-State Development Agency, CTA, and MTA-NYCT

Transit Modes Considered: All

Service Contracting Addressed? Yes, but in little detail

Performance Measures Identified: None

Summary: The purpose of the authors' research is to investigate current methods for collecting, analyzing, and reporting data on transit-related crime; identify problems with those methods; and make recommendations for improving the usefulness of the data. Through surveys, the authors identified two major problems that affect the collection and analysis of data on transit-related crime:

- The lack of a generally accepted and consistent definition of "transit-related crime"
- The FTA's use of FBI/UCR reporting guidelines, which means that only crimes for which there is an arrest are reported—"quality of life" crimes (e.g., vandalism and fare evasion) are not reported

The authors distinguish between "transit crime" and "transit-related crime." "Transit crime" includes "...criminal activities that occur on board transit vehicles or within the confines of the fixed transit system (e.g., in transit facilities, on the rail right of way)." "Transit-related crime" includes "...criminal activities that occur on or in an area that is not exclusively used for transit activities, e.g., a bus stop. A transit-related crime impacts a transit patron on the transit system but occurs in a mixed-use area that cannot be removed from the context of the surrounding community at large."

The authors recommend:

- Standardizing the compilation and aggregation of data reported to FTA
- Reorganizing crimes into one of three categories: Violent Crimes, Property Crimes, or Standard of Conduct Violations

Comments: There are no specific performance measures in this paper, but it contains a lot of information on reporting methods.

KFH Group, Institute for Transportation Research and Education, and Laidlaw Transit Services, Inc.

"Management Toolkit for Rural and Small Urban Transportation Systems"
TCRP Report 54
National Academy Press, Washington, D.C., 1999
http://nationalacademies.org/trb/publications/tcrp/tcrp_rpt_54-a.pdf

Context: Provides tools for small urban and rural provider to deliver high quality customer-oriented services

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: Urban and rural demand-response (general public and specialized)

Service Contracting Addressed? Yes

Performance Measures Identified:

- *Community-based:* Passenger perceptions through focus groups, press coverage
- *Transit availability:* Headways, service span, percent of trips requiring a transfer
- *Comfort & convenience:* Customer surveys, auto/drive time
- *Service delivery:* Road calls, missed trips
- *Service offered/utilization:* Ridership, vehicles in maximum service
- *Economics/productivity:* Passenger per revenue hour, mile
- *Vehicular capacity:* Bus stop capacity
- *Speed & delay:* Travel time, speed

Summary: The authors developed a guidebook to provide a customer-driven management system in small urban and rural transit systems. It is recommended that the guidebook's procedures serve as a self-assessment of the quality of existing service; in addition, the guidebook provides the transit manager an array of potential tools to improve the quality of customer service.

Seven primary areas of service quality are identified in this study. These are:

- Reliability
- Safety/security
- Convenience/accessibility
- Understandability/intelligibility
- Affordability
- Empathy

Within each of the seven areas, specific measures are provided along with the means to assess them.
The emphasis is on effective management to maximize the level of customer service provided by the small urban and rural transit provider, allowing them to address quality issues in a comprehensive and understandable matter. As such, the guidebook is successful. This study goes beyond measures internal to the organization that dominate much of the approach practiced by the agencies and also implicit in much of the statistical emphasis of the NTDB.

However, the emphasis on quality does not consider the severe resource limitations which small and urban systems face. The approach used by the authors relies heavily on the Total Quality Management (TQM) approach and does not consider the painful tradeoffs that transit agencies must make in the area of quality versus efficiency. For example, paratransit productivity can be enhanced in a computerized scheduling environment by increasing the system speed. However, the result will normally be a reduction in on-time performance. Transit systems, in many decisions, must balance what level of quality they can afford.

Comments: There are many unfortunate trade-offs specifically as they relate to providing paratransit service. Paratransit service is generally a larger component of total service cost in most small urban and rural transit systems. As a result, its impact on total operations is higher.

Increasing quality of service in paratransit is a double-edged sword. It can increase customer satisfaction in the short run but will lead to increased demand. With fixed-route service, that is clearly desirable as increased ridership brings a whole array of positives to the agency. However, a dramatic increase in ridership in paratransit without an offsetting improvement in productivity can, by itself, create a serious fiscal crisis for many transit agencies. What works for improving bus service in terms of quality enhancements can backfire when applied carelessly in a paratransit operation.

Khan, S.I., L. Eubanks, M. Mueller, and J. Robles

Common Performance Measures Practitioner's Guidebook
Prepared by the University of Colorado and the Colorado Department of Transportation
Federal Highway Administration, Washington, D.C., 1999

Context: A guidebook for performance measures based on five areas (mobility, agency cost, safety, user costs, and air quality) to perform simplified corridor/project analyses

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☒ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: None

Service Contracting Addressed? No

Performance Measures Identified: None

Summary: This document presents a methodology that used performance measures based on five areas (mobility, agency cost, safety, user costs, and air quality) to perform simplified corridor/project analyses. The baseline, no-build, and alternative conditions are generated, enabling the use of a ranking approach to select the best alternative.

Comments: Not specifically relevant to transit performance measures for service operators.

Khisty, Jotin C.

"Evaluation of Pedestrian Facilities: Beyond the Level-of Service Concept"
Transportation Research Record 1438
Transportation Research Board, Washington DC, 1998

Context: The 1985 HCM defines pedestrian level of service (LOS) in terms of speed levels and personal space. It recognizes that additional environmental factors must be taken into account to describe a pedestrian's perceived LOS, but does not provide guidelines on how to measure these environmental factors. This paper addresses environmental factors in describing a pedestrian's quality of service.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: None

Service Contracting Addressed? No

Performance Measures Identified: All associated with the pedestrian's perception

- *Community-based:* "Attractiveness"
- *Comfort & convenience:* "Comfort", "convenience", "safety", "security", "system coherence", and "system continuity"

Summary: Pedestrians, unlike drivers or passengers in a vehicle do not have control of environmental factors since they do not have the protection of a metal shell. Environmental factors therefore, have an important effect on the pedestrian's perception of LOS. The author states that qualitative environmental factors are as important as quantitative flow, speed and density factors for pedestrian facilities. An invitational quality exists for a well-designed pedestrian facility, the characteristics of which go beyond flow-speed-density measurements. Factors such as comfort and convenience are called out as being paramount for pedestrian facilities and transit stations.

Performance measures for assessing environmental factors were derived from a literature review. A total of seven performance measures were selected (listed on the previous page). These seven performance measures were then prioritized and weighted using the constant-sum, paired-comparison technique to determine the relative importance of each performance measure using group consensus. A five-point scale to give six levels of service was adopted for degree of satisfaction with/for each of the selected performance measures. Pedestrian routes were chosen and surveys administered to persons who use the pedestrian system on a regular basis. These surveys indicated the user's degree of satisfaction with each of the seven performance measures for each pedestrian route evaluated. A weighted average LOS is then computed and reported. This weighted average LOS for each route is based on the performance measures that describe the walking environment and supplements the quantitative LOS results obtained by using the 1985 HCM techniques.

Four primary applications of the methodology are provided: results used as a supplementary tool in evaluating the quality of pedestrian facilities; results used to identify or benchmark an ideal pedestrian route against which other routes may be compared; methodology used as a planning tool to develop future routes; and use results in budgeting funds for route improvements.

Comments: Most of the performance measures are described qualitatively and would therefore be described or rated differently by different individuals. A survey with a sufficient sample size would provide consensus results.

Kittelson & Associates, Inc.

"Transit Capacity and Quality of Service Manual, First Edition"
TCRP Web Document 6
Transportation Research Board, Washington, DC, 1999
http://nationalacademies.org/trb/publications/tcrp/tcrp_webdoc_6-a.pdf

Context: The TCQSM is intended to provide a single, comprehensive reference containing procedures to analyze bus, rail, and transit terminal capacity, and to develop procedures for evaluating transit quality of service from the passenger's point-of-view.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☒ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified:

- *Transit availability:* Service frequency, access time, intercity trips per day, hours of service, service coverage, passenger loading, transit stop access, percent person-minutes served, availability indexes
- *Comfort & convenience:* Passenger loads, amenities provided, on-time performance, headway adherence, transit-auto travel time, waiting area crowding
- *Vehicular capacity:* Bus stop capacity, bus facility capacity, rail facility capacity
- *Speed & delay:* Bus travel speed

Summary: The TCQSM is divided into five main sections. Part 5 (Quality of Service) is of greatest interest to this project, although Part 4 (Terminal Capacity) presents quality of service measures relating to terminal elements such as waiting areas, stairways, escalators, and walkways.

Quality of service is defined as the "overall measured or perceived performance of transit from the passenger's point of view." The TCQSM identifies six key performance measures and defines "A" to "F" levels of service to them, similar to the system the *Highway Capacity Manual* uses for highway facilities. (The transit chapters of the HCM 2000 also incorporate this material.) Thresholds between levels of service are designed to represent points where passengers would notice a change in service quality.

The following table presents the manual's quality of service framework, with service measures shown in all capital letters, and other important measures also indicated. Subsequent tables present the level of service ranges for each service measure.

Quality of Service Framework

Category	Service & Performance Measures		
	Transit Stop	**Route Segment**	**System**
Availability	FREQUENCY accessibility passenger loads	HOURS OF SERVICE accessibility	SERVICE COVERAGE % person-minutes served indexes
Comfort & Convenience	PASSENGER LOADS amenities reliability	RELIABILITY travel speed transit/auto travel time	TRANSIT/AUTO TRAVEL TIME travel time safety

Service Frequency LOS: Urban Scheduled Transit Service

LOS	Headway (min)	Veh/h	Comments
A	<10	>6	Passengers don't need schedules
B	10-14	5-6	Frequent service, passengers consult schedules
C	15-20	3-4	Maximum desirable time to wait if bus/train missed
D	21-30	2	Service unattractive to choice riders
E	31-60	1	Service available during hour
F	>60	<1	Service unattractive to all riders

Service Frequency LOS: Paratransit Service

LOS	Access Time (h)	Comments
A	0.0-0.5	Fairly prompt response
B	0.6-1.0	Acceptable response
C	1.1-2.0	Tolerable response
D	2.1-4.0	Poor response, may require advance planning
E	4.1-24.0	Requires advance planning
F	>24.0	Service not offered every weekday or at all

Service Frequency LOS: Intercity Scheduled Transit Service

LOS	Trips/Day	Comments
A	>15	Numerous trips throughout the day
B	12-15	e.g., midday and frequent peak hour service
C	8-11	e.g., midday or frequent peak hour service
D	4-7	Minimum service to provide choice of travel times
E	2-3	Round trip in one day is possible
F	0-1	Round trip in one day is not possible*

*Technically, a round trip might be possible, but the transit vehicle would likely return to its origin soon after arriving at its destination, not allowing any time for errands.

Hours of Service LOS

LOS	Hours per Day	Comments
A	19-24	Night or owl service provided
B	17-18	Late evening service provided
C	14-16	Early evening service provided
D	12-13	Daytime service provided
E	4-11	Peak hour service/limited midday service
F	0-3	Very limited or no service

Fixed-route: number of hours per day when service is provided at least once an hour.
Paratransit: number of hours per day when service is offered.

Service Coverage LOS

LOS	% Transit-Supportive Area Covered
A	90.0-100.0
B	80.0-89.9
C	70.0-79.9
D	60.0-69.9
E	50.0-59.9
F	<50.0

Transit-Supportive Area: The portion of the area being analyzed that has a household density of at least 7.5 units per gross hectare (3 units per gross acre) or an employment density of at least 10 jobs per gross hectare (4 jobs per gross acre).
Covered Area: The area within 0.4 km (0.25 mi) of local bus service or 0.8 km (0.5 mi) of a busway or rail station, where pedestrian connections to transit are available from the surrounding area.

Passenger Load LOS

LOS	Bus		Rail		Comments
	m^2/p	p/seat*	m^2/p	p/seat*	
A	>1.20	*0.00-0.50*	>1.85	*0.00-0.50*	No passenger need sit next to another
B	0.80-1.19	*0.51-0.75*	1.30-1.85	*0.51-0.75*	Passengers can choose where to sit
C	0.60-0.79	*0.76-1.00*	0.95-1.29	*0.76-1.00*	All passengers can sit
D	0.50-0.59	*1.01-1.25*	0.50-0.94	*1.01-2.00*	Comfortable standee load for design
E	0.40-0.49	*1.26-1.50*	0.30-0.49	*2.01-3.00*	Maximum schedule load
F	<0.40	*>1.50*	<0.30	*>3.00*	Crush loads

*Approximate values for comparison. LOS is based on area per passenger.

Reliability LOS: On-Time Performance

LOS	On-Time Percentage	Comments*
A	97.5-100.0%	1 late transit vehicle per month
B	95.0-97.4%	2 late transit vehicles per month
C	90.0-94.9%	1 late transit vehicle per week
D	85.0-89.9%	
E	80.0-84.9%	1 late transit vehicle per direction per week
F	<80.0%	

Applies to routes with headways greater than 10 minutes.
*user perspective, based on 5 round trips/week of their travel on a particular transit route with no transfers
"On-time" = 0-5 minutes late departing published timepoint (fixed-route)
arrival within 10 minutes of scheduled pick-up time (deviated fixed-route)
arrival within 20 minutes of scheduled pick-up time (paratransit)

Reliability LOS: Headway Adherence

LOS	Coefficient of Variation
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

Applies to routes with headways less than or equal to 10 minutes. The coefficient of variation is the standard deviation of headways divided by the scheduled headway.

Transit/Auto Travel Time LOS

LOS	Travel Time Difference (min)	Comments
A	≤0	Faster by transit than by automobile
B	1-15	About as fast by transit as by automobile
C	16-30	Tolerable for choice riders
D	31-45	Round-trip at least an hour longer by transit
E	46-60	Tedious for all riders; may be best possible in small cities
F	>60	Unacceptable to most riders

Comments: The TCRP A-15A project is working on a Second Edition of the TCQSM, scheduled to be published in early 2003. Phase 1 of that project tested the quality of service measures in Chicago, IL; Albuquerque, NM; Gainesville, FL;, and a rural system in northwest Missouri. In addition, the TCQSM is known to have been applied for various purposes in Tampa, FL; Washington, DC; San Antonio, TX; and Birmingham, AL.

At the time of writing, based on the feedback received from these tests and applications, it is expected that all of the identified measures for fixed-route urban service will continue to be presented in the Second Edition. However, most of the measures will likely be revised in some manner, ranging from changing LOS thresholds, to revising definitions, to adding additional factors. In addition, an entirely separate framework for demand-response transit has been developed.

Kocur, George

A Unified Approach to Performance Standards and Fare Policies for Urban Transit Systems
Prepared for U.S. DOT, Washington, D.C., December 1982

Context: This document provides policy guidelines for local transit operators to optimize their bus system's service. It considers routing, fare levels, headway times, and vehicle size issues, and is sensitive to several different system objectives.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Hartford, Connecticut

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? No

Performance Measures Identified:

- *Service delivery:* Wait time, walk time, headway times, route structure, stop spacing
- *Service offered/utilization:* Ridership
- *Economics/productivity:* Cost, deficit
- *Speed & delay:* Wait time, walk time

Summary: This paper reaches a series of general conclusions about bus transit system optimization based on balancing route consolidation, headway times, route structure/meanders, stop spacing, express service, park and ride, and transit fare decisions. It presents a series of scenarios and cause-and-effect examples that are intended to give transit operators a general understanding of how these variables can interact to increase or decrease revenue, wait time, trip time, service area, or cost. If the desired goal is a lower average wait time, it suggests increasing stop spacing and decreasing headway, resulting in lower overall wait time and (hopefully) increased ridership.

In his conclusion, the author emphasizes route review on a corridor-by-corridor basis, with an eye towards achieving optimal cost per passenger and revenue per passenger ratios by balancing headway, fare, and stop spacing.

Comments: On the whole, this paper is an excellent overview of desirable traits in a balanced bus transit system and offered specific suggestions for specific scenarios. It also acknowledges that, while its suggestions are generally applicable, special cases may need different or more detailed analysis for optimization. Little mention is made of actual performance measurement techniques, although it is assumed that operators have such measures at their disposal to evaluate the effects of their changes.

Kosky, Scott

Performance Evaluations for Rural Transit Systems
Technical Assistance Brief #5
Rural Transportation Assistance Program (RTAP), 1990

Context: The author states that performance measures are needed to make determinations about a service's efficiency, effectiveness, and benefit to the community.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: Rural (general public and specialized)

Service Contracting Addressed? No

Performance Measures Identified:

- *Economics/productivity:* Cost per passenger, per mile, per service mile

Summary: The author was the manager of a rural transit agency in Southwestern Missouri and indicates quite clearly in the introduction the need for goals that balance social and financial goals. It is clearly stated that service quality should be the number one goal for the rural transit manager. He also states that goals need to be quantifiable.

Eight goals are given. These are all financial goals (e.g., cost per passenger, cost per hour, and cost per mile) and do not measure service quality—only efficiency and effectiveness. The paper raises the importance of service quality but provides no guidance on how to reach that, falling back on "tried and true" financial measures. The author goes as far as to call on-time performance a non-quantifiable measure.

Comments: This paper demonstrates one of the difficulties in transit management. There is an understanding of quality, but managers proceed to fall back on "tried and true" financial measures.

Kowloon-Canton Railway Corporation

Public Information Documents and Personnel Communication with Dr. Siu Lok Kee
KCRC, Shatin, Hong Kong

Context: Documents for public information

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: KCRC trains

Transit Modes Considered: Commuter rail

Service Contracting Addressed? No

Performance Measures Identified: (target in brackets)

- *Community-based:* Response to passengers' inquiries and opinions by phone (within two working days) or by letter (within six working days)
- *Comfort & convenience:* Train washing (99%); on-train air conditioning failures per month (<=3); Availability of: escalators (99%), gates (99%), information system at platform (99%); add value machines (99%); inquiry processors (99%); first class processors (99%);
- *Service delivery:* Service delivery (99%)
- *Speed & delay:* Punctuality: trains greater than two minutes late (99%); major delays of greater than or equal to 20 minutes (none)

Summary: Documents for public consumption that list the performance measures for the KCRC trains; the operators or contracting agreements are not detailed. See also the agency interview.

Kunkel, Mary Jo, and Michael J. Demetsky

"Decision Procedures for Paratransit Management."
Transportation Research Record 863
National Academy Press, Washington, D.C., 1982

Context: Provides paratransit managers with a decision framework for evaluating paratransit services and presents a set of procedures for implementation.

Applicability to G-6 Project:
- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Tidewater Transit

Transit Modes Considered: Urban demand-response (general public and specialized)

Service Contracting Addressed? No

Performance Measures Identified:
- *Community-based:* Public awareness of transit system
- *Transit availability:* Accessible vehicles
- *Comfort & convenience:* Safety, vehicle cleanliness, driver courtesy
- *Service delivery:* Directness of service
- *Economics/productivity:* Cost per mile, cost per passenger, direct hours per employee, administrative hours per vehicle
- *Speed & delay:* Travel time versus automobile

Summary: This paper develops a dual approach to assessment of paratransit systems. Any evaluation needs to be conducted both from the point-of-view of the agency and the point-of-view of the user. As a result, a dual set of standards is set up.

Cost efficiency standards set up from the point-of-view of the agency include:
- Expense per mile
- Office hours per vehicle
- Cost per passenger
- Revenue/cost
- Vehicle hours per employee
- Level of occupancy

The study also sets up customer-oriented measures for evaluation. These measures are often in conflict with meeting the cost efficiency goals and include:
- Travel time
- Safety
- Cost of fare
- Comfort
- Service directness/speed
- Public awareness

Paratransit is seen as one potential transit mode among alternatives. The authors propose a multi-modal approach to review how paratransit effectively compares to other modes. They contend it is especially useful if, through the course of the performance evaluation, service quality is deemed inadequate.

Comments: The balanced perspective between agency and user is more common in performance evaluations of the 1990s then the ones reviewed in the 1980s. It is an approach that, in perspective, looks ahead of its time. The complexity of the model may make transit agency implementation (especially for small urban and rural systems) a distinct challenge.

Kuprenas, John, and Ali Nowroozi

Identification and Analysis of Local Agency Transit Project Performance
CalTrans, Sacramento, CA, 2000

Context: This paper addresses positive and negative management factors that effect local agency satisfaction with project delivery, budget performance, and schedule performance.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: None

Service Contracting Addressed? No

Performance Measures Identified:

- *Service delivery:* Surveys of project contractors.

Summary: The paper found that the primary success factors were “CalTrans Staff Assistance” and “Established Funding Procedures.” The primary hindrance factors were “Bureaucracy” and “Poor Local Staff.” The paper concludes with a call for more standardized survey procedures to evaluate such management techniques. Little is offered in the way of specific performance measures for other agencies, except a general affirmation of the usefulness of surveys to evaluate the success or failure of transit system projects.

Comments: This paper is of more local relevance to CalTrans than of general applicability to other systems seeking similar performance measures.

Lee, Douglass

"Transit Cost and Performance Measurement"
Transport Reviews, pp. 147-170
Vol. 9, No. 2, 1989

Context: This paper presents a systematic, hierarchical set of performance indicators for use in evaluating the performance of transit systems. It is designed for both internal assessment and external comparison between systems, depending on the system's needs and available data.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: The paper used Section 15 (now National Transit Database) data for the largest 50 transit systems in the U.S. No single system was singled out for evaluation, but several systems were used as illustrative examples throughout the paper.

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified:

- *Service delivery:* Trips per hour, places per vehicle, vehicle miles per hour, route miles per square mile, trips per capita
- *Service offered/utilization:* Passengers per vehicle hour, passengers per place
- *Economics/productivity:* Cost per vehicle hour, revenue per vehicle hour, deficit per vehicle hour, revenue per passenger, cost per passenger, deficit per passenger, operating ratio (cost per vehicle hour by revenue per vehicle hour), revenue per trip

Summary: This paper provides an excellent overview of transit cost and performance measures. It divides performance measures into three tiers. The first tier comprises high-level aggregate measures that are commonly available, including cost per vehicle hour, revenue per vehicle hour, passengers per vehicle hour, revenue per passenger, etc. Such data are easily gathered and allow for objective, meaningful comparison between different agencies and systems. The second tier adds more detail, breaking each measure into its component sub-factors, such as operations costs, maintenance costs, and administration costs. This allows for more fine-scale analysis, resulting in a more accurate picture of a system's performance. Finally, the third tier adds another level of significant detail, focusing on specific, ground-level measures such as base wage, crew size, fringe benefits, etc. This final tier offers the potential for an extremely detailed understanding of a system's operations yet requires significant data gathering.

Taken as a whole, this paper advocates a standardized approach to performance measures that is responsive to agencies' needs and resources. Some systems may require detailed, tier three measures to achieve satisfactory performance reporting, where others may be adequately served by tier one or two measures. This paper provides a broad approach that is applicable to a wide variety of needs and circumstances.

Leonard II, John D., and Marcelo Oliveira

"Towards an Areawide Service Measure"
Transportation Research Circular
4th International Symposium on Highway Capacity, June 2000

Context: Written at the same time as Chapter 30 of the 2000 *Highway Capacity Manual* (HCM 2000), this paper describes the characteristics of a "good" area-wide performance measure, develops such a measure, and applies it in Atlanta, GA.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None specifically

Transit Modes Considered: All, in a very general sense

Service Contracting Addressed? No

Performance Measures Identified:

- *Transit availability:* Accessibility
- *Speed & delay:* Accessibility, the authors' area-wide measure

Summary: The authors reference two definitions of accessibility from HCM 2000. These definitions are:

- "Accessibility can be measured in terms of the number of trip destinations that can be reached within a selected travel time for a designated set of origin locations (such as a residential zone). The results of each origin zone are tabulated and reported in terms such as: X percent of the homes in the study area can reach Y percent of the jobs within Z minutes."
- "A mean access time (trip time) for 100 percent of the origins and destinations might also be reported. Accessibility is computed by finding the shortest path travel times from the origin zone to all destination zones in the region. Destination zones that are accessible within the desired travel time are identified and the number of trip destinations represented by these destination zones is tallied to obtain the accessibility performance measure."

The authors note that, in the HCM research, the terms "accessibility" and "mobility" tended to be used interchangeably. The authors distinguish between these terms: "...Accessibility describes the ease at which a set of origins are served by a single destination ... while mobility describes the ease at which a single origin may travel to a set of multiple destinations." The authors also warn that, to calculate the HCM 2000 accessibility measures, the number of origins and destinations must be known.

The authors propose an area-wide performance measure based on their identification of the desirable characteristics of such a measure. These desirable characteristics are:

- The measure describes an individual traveler's experience.
- The measure is sensitive to recurring and nonrecurring congestion.
- The measure does not depend on the size or shape of the study area.
- The measure can be compared across times and across different modes and facilities.
- The measure can be calculated in real time.

The proposed measure is defined as:

$$T = \frac{1}{n \times m} \sum_{i=1}^{n} \sum_{j=1}^{m} \frac{t_{ij}}{d_{ij}}$$

T is the average area-wide service measure for all origins, *n* is the number of origins, *m* is the number of destinations, t_{ij} is the shortest path travel time between origin *i* and destination *j*, and *d* is the Euclidean distance between origin *i* and destination *j*. According to the authors, the benefits of the proposed measure are:

- The measure is consistent with HCM 2000 performance measures for specific facilities.
- Travel time is common to all HCM 2000 facility types and can be aggregated.
- Travelers experience travel time directly.

To calculate the proposed measure, the following inputs are required:

- Origin and destination locations
- A representation of the transportation network (links and nodes)
- Travel times for all links
- Delays at each node

Several algorithms are available for calculating the shortest paths between origin-destination pairs. In the authors' Atlanta example, travel times along the shortest paths were calculated from speed data collected by Atlanta's transportation management center, which updates speeds every five minutes. It took the authors approximately 1.5 minutes to find the shortest path travel times for the example network using a 200 MHz Pentium Pro computer and widely available programming and Internet software. Isochrones were used to graphically represent travel time from a single origin to all destinations.

Comments: The measures described in this report are not directed specifically at transit systems, but the basic ideas could be applied by a transit agency. Isochrones like the authors' would be particularly attractive for providing travel time information to transit users. Note that accessibility was categorized as both an Availability measure and a Speed & Delay measure, based on the HCM 2000 definitions. The authors' proposed measure is only a Speed & Delay measure.

Levine, Jonathan

"Towards a Level-of-Service Measure for Mass Transit"
Journal of the Transportation Research Forum, pp. 362-367
Vol. XXVIII, No. 1, 1987

Context: This paper was written to initiate discussion on developing a level of service measure for transit services.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? No

Performance Measures Identified:

- *Transit availability:* Part of level of service
- *Comfort & convenience:* Part of level of service
- *Service delivery:* Part of level of service
- *Speed & delay:* Part of level of service

Summary: The main point of this article is that there are too many performance measures in use, which is confusing and does not make it easy to compare different transit operators with one another. The author postulates that all these individual performance measures could be summarized by a single level of service (LOS) measure, similar to that used in street and highway planning. In vehicle travel time, service frequency, accessibility/out-of-vehicle travel time, service reliability, and comfort/security were the major areas considered by the author in creating a LOS measurement. Weighting these different areas represents the true challenge in creating the transit LOS measurement, and the author concedes that this is the reason there has not been consensus on creating a transit LOS.

Levine, Lenny

"How to Beat (or at Least Stay Even With) The Paratransit Juggernaut"
Metro Magazine, July/August 1997, p. 58

Context: Magazine article

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☒ Applications of technology

Transit Systems Evaluated: King County Metro (Seattle, WA), Springs Transit (Colorado Springs, CO), Pace Suburban Bus (Chicago, IL), Laidlaw Transit Services (Jamestown, CA)

Transit Modes Considered: Urban demand-response (specialized)

Service Contracting Addressed? No

Performance Measures Identified: None

Summary: Levine looks at activities in Seattle, Colorado Springs, and Chicago to improve to reduce the costs of paratransit services. Levine examines practices that aim at better integrating paratransit and fixed-route bus service to improve the cost-effectiveness of the latter. New technologies for dispatching and its role in improving paratransit operations are also examined. Case study examples of cost-reduction activities employed include revenue brought in by bus shelter ads in Colorado Springs, and Pace's work in Chicago to keep its fleet of paratransit buses new and in good condition, in order to improve paratransit operation efficiency.

Levine also presents travel training as an option employed by many major transit agencies in reducing the costs of paratransit service by integrating paratransit patrons into the fixed-route bus systems where possible. Finally, Levine presents advice from the director of operations for Laidlaw Transit Services, Inc., in Jamestown, CA, on ways to reduce paratransit costs.

Levinson, H.S., M. Golenberg, and K. Zografos

Transportation System Management - How Effective? Some Perspectives on Benefits and Impacts
Transportation Research Record 1142
Transportation Research Board, Washington DC, 1987

Context: The paper was written to discuss Transportation System Management (TSM), the nature of its impacts, performance measures to measure impacts, and analysis techniques to quantify improvements.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: All, in general terms

Service Contracting Addressed? No

Performance Measures Identified:

- *Transit availability:* Transit coverage, peak and off-peak coverage.
- *Comfort & convenience:* Average vehicle occupancy (persons/transit vehicle, load factor (peak and off-peak).
- *Service offered/utilization:* Bus miles per 1000 residents.
- *Economics/productivity:* Capital cost (total and annualized), O&M costs per bus hour or bus mile, total daily riders (daily riders/bus mile or bus hour), annual riders by line or system (annual rides/capita in service area), annual transit subsidy, subsidy per passenger.
- *Vehicular capacity:* Capacity (persons per hour, passengers/car unit/hour).
- *Speed & delay:* Traffic volume, person flow, travel time (person-hours of travel), vehicle hours of delay, safety, average speed, delay in sec/person.

Summary: The authors state that TSM is in transition, provide a description of the TSM process, discuss the nature of TSM impacts, suggest performance measures for assessing TSM impacts, then discuss impact assessment techniques.

The TSM process is described in steps that flow from the analysis of problems to the development of an improvement program. The steps include the analysis of the problem and its setting, the identification of likely solutions, screening actions to select appropriate ones, the assessment of performance, combining actions into groups, and the development of an improvement program. The nature of TSM impacts - that these are short-range low-cost improvements, whose total impacts are less than that of major new construction or long-range transportation improvement is discussed. The authors present the concept of an impact-chain, where a given action produces a chain of impacts, but only some of these impacts are primary or basic ones. The other impacts are secondary and could be derived, treated qualitatively or otherwise ignored. The evaluation procedure could therefore focus on measuring one or two basic (primary) impacts for any solution, thus simplifying the analysis especially when resources are limited.

The selection of performance measures can be simplified by distinguishing between three types of measures: basic (requiring data collection or direct estimation), derived, and intermeasures (that show relationships between measures). A list of each of these types of measures is presented. Many of these can be applied to transit. Qualitative secondary measures should also be considered in assessing improvement effectiveness. The authors also caution that the listed performance measures will not apply to every specific problem and the relevance of each is dependant on the nature of the problem, goal or action.

Impact assessment techniques should be selected such that they are "easy to use, produce reasonable results and provide reliable answers (estimates) to specific problems." The authors group impact assessment techniques into three groups based on amount of information available and into several categories based on the type of technique. Each of these categories is discussed in brief. Categories of specific interest to transit include mode-choice models (usually not appropriate for TSM type improvements), direct-demand estimates, the use of elasticity factors, transit performance analysis and transit operating and maintenance cost analysis. The choice of the specific application procedure is influenced by level of detail and desired accuracy. The authors' guidance is to quantify as few impacts as necessary with careful consideration for relevancy. They state "Simplicity and responsiveness are the underlying themes".

Comments: The paper includes a table that relates bus travel times and speeds as a function of stop spacing and traffic congestion. The paper lists examples of impacts estimated from literature review, ongoing studies and actual experience: these are expected to be useful in making initial estimates and in checks of reasonableness.

Li, Jianling, and Martin Wachs

"A Test of Inter-modal Performance Measures for Transit Investment Decisions"
Transportation, pp. 243-267
Vol. 27, 2000

Context: This paper addresses inadequacies in traditional performance measures and proposes new performances measures that are more useful for inter-modal comparisons.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Two systems are evaluated: The Los Angeles-Long Beach Corridor (LACMTA) and the Market/Judah Corridor in San Francisco (MUNI).

Transit Modes Considered: Urban fixed-route bus, light rail

Service Contracting Addressed? No

Performance Measures Identified:

- *Service offered/utilization:* Unlinked passenger trips, passenger miles
- *Economics/productivity:* Total cost, revenue capacity miles, revenue capacity hours

Summary: The authors criticize traditional performance measures such as operating cost per revenue mile, operating cost per revenue hour, passenger boardings per revenue vehicle mile, etc., and claim that such measures have two major flaws. They assert that such measures are particularly inadequate when comparing different transit modes, such as light rail and bus.

Their first and most significant objection to such measures is that the measures do not factor in capital costs. Because of this, the authors claim that performance indicators based solely on operating costs are inadequate measures of the true costs of different modes, such as light rail systems versus bus systems. Their second objection is that costs per vehicle hour and costs per vehicle mile do not take into account the wide variation in passenger capacity that different modes offer, thus missing an important factor in service consumption.

To address the first concern, the authors posit a set of "enhanced measures" that measure annual total cost by annualizing the capital costs of each mode over the economic lifetime of its components and using the cost allocation method to associate operating statistics such as vehicle miles, vehicle hours, etc. To address the second, they computed the maximum design capacity of bus and light rail cars to obtain passenger miles and unlinked passenger trip figures.

In applying these "enhanced measures" to the two case studies, the authors found that light rail was significantly more expensive to build and maintain than bus systems. They then go on to claim that such enhanced measures could be used to more accurately justify the allocation of FTA New Starts funds.

Comments: This paper provides some interesting criticism of traditional performance measures and makes a strong argument for the need to include original capital costs in overall system performance measures. The approach to annualizing capital costs over the life of the system seems sound, but there are several areas where unsupported assumptions were made that weakens the strength of the conclusions. The objection to cost per vehicle hour or vehicle mile is less relevant, as performance measures such as costs per passenger hour already exist.

Lieberman Research East

2000 Citywide Survey: New York City Residents' Perceptions of New York City Transit Services
Preliminary Draft
Prepared for Metropolitan Transportation Authority – New York City Transit, Great Neck, NY, 2000

Context: Results of annual survey

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☒ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: MTA-New York City Transit

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? No

Performance Measures Identified: See the summary.

Summary: The Citywide Survey is an annual telephone survey of NYC residents. It is intended to monitor the public perceptions of the NYC subway (primarily) and buses and identify trends in customer satisfaction. This research aids in identifying and prioritizing areas for subway service improvement, detecting and prioritizing areas for subway environment enhancement, assisting in the development of programs that meet customers' needs, and directing the development of marketing actions and messages targeted toward customer attraction and retention. The factors surveyed include:

- Overall subway service and its attributes
  - Removal of scratch graffiti from inside subway cars
  - Feeling of safety and security in subway cars
  - Safety from accidents
  - Getting there on time
  - Cleanliness of subway car interior
  - Not having to wait too long
  - Announcements on trains regarding delays
  - Clarity of announcements
  - Temperature in subway cars
  - Overall comfort of the trip
  - Crowding on trains during rush hour (having space to sit or stand)
  - Absence of the homeless and panhandlers in subway cars
  - Speed of travel
  - Courtesy of subway conductors
- Overall station environment and its attributes
  - Crowding on platforms during rush hour
  - Lighting of stations
  - Level of information about train delays in the stations
  - Clarity of announcements
  - Courtesy of token booth clerks
  - Length of lines at token booths
  - Cleanliness of stations and areas near token booths
  - Presence of police officers in stations
  - Feeling of safety and security in stations

- Removal of graffiti from station walls and columns
- Absence of the homeless and panhandlers

- Perceptions of subway service improvements over the past two years and expectations of service quality over the next two years
- NYC Transit's reasonableness compared to other transportation modes
- Value/cost of the fare
- Perception and usage of MetroCard vending machines
- Satisfaction with local bus service
  - Safety and security on buses
  - Announcement of major stops
  - Clarity of announcements
  - Temperature on buses
  - Cleanliness of buses
  - Courtesy of bus operators
  - Reliability of schedules
  - Crowding on buses
- Awareness of the agency's advertising
- Internet usage of customers

Comments: The report lists many service quality characteristics but no specific performance measures. NYC residents were asked their perceptions of the causes of bus delay and bunching.

LIRR Commuters Campaign

"The LIRR Passengers Bill of Rights" and other documents
Downloaded from http://www.lirrcommuters.org/ on October 24, 2001

Context: Articles from the LIRR Commuters Campaign web site

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology
- ☒ Other: Criticism of existing transit service and performance measurement system

Transit Systems Evaluated: MTA - Long Island Rail Road (LIRR)

Transit Modes Considered: Commuter rail

Service Contracting Addressed? No

Performance Measures Identified: (Many general ones)

- *Service delivery:* Passenger hours late

Summary: These articles include the LIRR Passengers Bill of Rights, discussion of the issues that resulted in formation of the LIRR Commuters Campaign, "The 'On-time Performance' Fraud," "The Ticket Machine Fiasco," and suggested improvements to the LIRR.

The LIRR Passengers Bill of Rights calls for:

1. Safe, clean, reliable, and comfortable trains
2. Courteous treatment of passengers
3. The ability to provide direct and timely feedback to LIRR management
4. Posting of the LIRR Passengers Bill of Rights in all trains and stations
5. On-time performance, or detailed explanations of delays and alternative travel options
6. Preferential seating for paying passengers (as compared to non-paying employees)
7. Clear, intelligible, and timely announcements on trains and platforms
8. Clean windows
9. Clear posting of peak and off-peak times and penalty fares
10. Informing and consulting with passengers about changes to frequency, reliability, comfort, and/or safety
11. Reasonable safety on board, at stations, and in parking areas
12. Accurate, timely information about on-time performance, delays, and service interruptions (via the web)

The self-described issues that resulted in formation of the LIRR Commuters Campaign are:

1. Extreme lack of responsiveness to passenger needs and suggestions
2. Being "lied to publicly" about on-time performance
3. Stopping maintenance on old equipment, combined delayed receipt of new equipment
4. The "unsuitability and lack of quality" of the new equipment
5. Horn volume

"The 'On-time Performance' Fraud" discusses the following issues:

- What does on-time performance measure?
- Manual vs. automatic train timings
- Slack time in schedules

- Schedule adjustments
- Cancelled trains
- "The 59-minute train"
- The delay analysis process
- Recommended development of a passenger hours late index and recommended cross-referencing of delays by season, date, time, day, weather, crew, train, equipment, branch, location, passenger load, and other factors

"The Ticket Machine Fiasco" discusses issues associated with replacing ticket agents with ticket vending machines.

Suggested improvements to the LIRR include:

- Change the on-time performance measure to "passenger hours late" (or report both).
- Enforce policies on preferential seating of paying passengers, smoking, loud music or other electronic devices, closing off of cars, and feet on seats.
- Establish a web site with real-time information, where passengers can enter complaints.
- Improve the courtesy and professionalism of crews.
- Improve accuracy and timeliness of announcements.
- Improve cleanliness.
- Improve safety.
- Use proper grammar.

Comments: These documents highlight how differently passengers and operators can perceive transit service and provides insights into what passengers expect of transit service.

Litman, T.

"Measuring Transport: Traffic, Mobility, and Access"
TDM Encyclopedia
http://www.vtpi.org/tdm/
Victoria Transport Policy Institute, Victoria, Canada

Context: This online encyclopedia is produced by the Victoria Transport Policy Institute to increase understanding and implementation of transportation demand management (TDM).

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None; general discussion relating mainly to roads

Transit Modes Considered: None

Service Contracting Addressed? No

Performance Measures Identified: The performance measures, which are divided into traffic, mobility, and access, do not specially relate to transit.

Summary: The TDM Encyclopedia discusses performance indicators; however, it is written predominately from a roadway point of view. Some general comments on the performance indicators or the three different perspectives of transportation may be relevant and are given below.

It is stated that performance indicators are practical ways to measure progress toward goals and objectives. Examples of performance indicators used for transportation evaluation include traffic counts, roadway level of service, transit boardings, costs per mile, crash rates, and customer satisfaction survey results. It is suggested that, in most cases, no single indicator is adequate, so a set of indicators that reflect various goals and perspectives are used, with how the indicators are selected, weighted, and presented implicitly defining the value placed on different objectives.

It is also stated that transportation performance indicators can reflect different perspectives about the nature of transportation, referred to as traffic (vehicle movement), mobility (movement of people or goods), and access (the ability to reach desired goods, services, and activities) perspectives. Examples of performance measures for each of these categories are:

- *Traffic* performance indicators include roadway level of service, average traffic speeds, congestion delay, parking supply, vehicle costs, and crash rates.
- *Mobility* can be measured in person-miles, ton-miles, and travel speeds, is more difficult to measure than traffic because it requires tracking people and goods rather than vehicles.
- *Access* is evaluated based on the time, comfort, and financial costs of travel, which traffic modelers call the "generalized cost."

The following table gives detail on some performance measures, which are predominately related to roads, rather than transit.

	Traffic	Mobility	Access
Definition of Transportation	Vehicle travel	Person and goods movement	Ability to obtain goods, services, and activities
Unit of Measure	Vehicle miles	Person-miles and ton-miles	Trips, generalized costs
Assumptions Concerning What Benefits Consumers	Maximum motor vehicle travel and speed	Maximum personal travel and goods movement	Maximum transport choice and cost efficiency
Consideration of Land Use	Treats land use as an input, unaffected by transportation decisions	Recognizes that land use can affect travel choice	Recognizes that land use has major impacts on transportation
Favored Transportation Improvement Strategies	Increasing road and parking facility capacity, speeds, and traffic safety	Increased roadway, transit ,and rail system capacity, speeds, and safety	Management strategies and improvements that increase transport system efficiency and safety
Implications for TDM	Generally considers vehicle travel reductions undesirable, except if congestion is extreme	Supports TDM strategies that improve personal and freight mobility	Supports TDM whenever it is cost effective

Los Angeles County Metropolitan Transportation Authority

MTA's State of the Bus System Report
LACMTA, Los Angeles, CA, March 2001

Context: Annual progress report.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Los Angeles County MTA

Transit Modes Considered: Urban fixed-route bus, urban demand-response (specialized)

Service Contracting Addressed? No (some service is contracted, but not addressed in any detail in the report, other than a commitment to monitor that service quality meets the terms of the contract)

Performance Measures Identified:

- *Comfort & convenience:* Reliability, number of standees per bus, bus appearance, ease of boarding, number of security cameras, travel time
- *Service delivery:* Monthly passenger complaints, operator courtesy, miles between road calls, bus accident rate, average fleet age, peak buses in service, percent scheduled buses operated
- *Service offered/utilization:* Annual boardings, annual service hours
- *Economics/productivity:* Cost per revenue hour

Summary: This report is intended for public consumption, with short, punchy statements and lots of graphics. The report highlights the positive things that MTA accomplished over the prior year, but it is not clear from the report whether all of the agency's goals are being presented, or just those that showed an improvement. Quantitative performance measures, including those listed on the previous page, are used to support assertions of improved performance in a number of areas, while in other cases, the fact that an intended action was taken (e.g., instituting a Bus Cleanliness Inspection Program) constitutes the measure of whether a goal was met.

Since October 1996, the MTA has been operating under a Consent Decree by the U.S. District Court for the Central District of California. This decree identifies actions that MTA must make over a ten-year period to improve transit service. Many of these actions are community-related, e.g., provide new or modified routes to improve access to jobs, schools, and health facilities for transit dependents, and maintaining affordable fares. Reducing overcrowding is another action. The report describes how the MTA has worked to implement the Consent Decree, but notes that some issues remain in dispute, including the level of investment required for new service and passenger loading standards.

The remainder of the report describes future actions the MTA intends to take to continue to improve performance.

Loukaitou-Sideris, Anastasia, and Robin Liggett

"On Bus-Stop Crime"
Access, No. 16, pp. 27-33
University of California Transportation Center, Berkeley, CA, Spring 2000

Context: Article about the relationship between the bus stop characteristics and crime

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology
- ☒ Other: Discussion of transit crime issues

Transit Systems Evaluated: Los Angeles MTA (60 downtown bus stops evaluated)

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? No

Performance Measures Identified:

- *Comfort & convenience:* Perceived safety

Summary: The bus stop environment characteristics identified in this article that may make waiting passengers feel unsafe include:

- Isolation (i.e., little pedestrian activity, vacant buildings, and/or poor visibility from nearby stores)
- Presence of vagrants
- Nearby poorly maintained buildings
- Surrounding land uses that may be associated with crime and violence (e.g., bars and liquor stores)
- Litter and broken glass
- Nearby fenced lots
- Graffiti
- Proximity of hiding places for potential criminals
- On-street parking
- Level of illumination

The authors suggest that moving bus stops away from areas with the above characteristics, improving cleanliness and upkeep in the bus stop vicinity, removing potential hiding places, improving lighting, and improving shelter design can improve passenger safety at bus stops.

Comments: This paper's findings are consistent with those of Widawsky's reports about perceived security in the New York City rail system. Like Widawsky's reports, this article discusses issues and solutions, not performance measures.

An interesting point made is that isolation contributes to more serious crimes while overcrowding may contribute to less serious crimes such as pickpocketing.

Loveless, Shirley

"Access to Jobs: Intersection of Transportation, Social, and Economic Development Policies: Challenge for Transportation Planning in the 21st Century"
Refocusing Transportation Planning for the 21st Century, Transportation Research Board Conference Proceedings 20
National Academy Press, Washington, D.C., 2000

Context: Resource paper about problems faced in providing mobility to support welfare-to-work initiatives

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated:

Transit Modes Considered: All (generally)

Service Contracting Addressed? No

Performance Measures Identified:

- *Transit availability:* Mobility and accessibility for a specific population, availability
- *Comfort & convenience:* Convenience, cost
- *Service delivery:* Reliability

Summary: The author uses the U.S. Department of Transportation's definitions for access and mobility. These definitions are:

- *Mobility* – "potential for movement [that] expands the geographic choices available to people and to businesses"
- *Access* – "potential for spatial interaction with various desired social and economic opportunities"

The author describes each mode in terms of convenience, availability, reliability, maximum passenger load, and commuter cost, but only in general terms (e.g., "low", "high"). Other categories in the author's table (not reproduced here) are service type, service configuration, and other characteristics.

One of the author's conclusions is that welfare-to-work program evaluations should be measured by customer needs rather than by more traditional transit agency measures such as farebox recovery ratios. For the G-6 work, this implies that transit performance measures ought to be tailored to specific populations of users.

Comments: The measures presented in the author's table are not quantified into levels of service. The qualitative distinctions (e.g., "high") do not seem to specifically reflect the needs of the most critical segment of the welfare-to-work population (which is really the segment of most concern because that is the segment that is currently unable to reach and maintain employment). For example, the author emphasizes in the paper that "appropriate" jobs for welfare-to-work clients may be assigned to shifts outside normal commuting hours. Peak hour express bus service will not be at all convenient for welfare-to-work clients who face this roadblock.

The qualitative distinctions in the table also are not particularly useful in comparing characteristics of specific modes. For example, regular bus and light rail are said to both have "limited night and weekend service" when the service provided can actually differ quite a bit between the two modes and between different systems.

In the table, trade-offs between the categories of characteristics should be kept in mind. Americans with Disabilities Act (ADA) provisions ought to be kept in mind, too. For example, the fare for a complementary paratransit service implemented in response to the ADA is restricted to make it consistent with the fares charged for other services in the transit system.

MacDorman and Associates

Virginia Public Transportation Performance Evaluation Study
Prepared for Public Transportation Division Virginia Dept. of Highways and Transportation
MacDorman and Associates, March 1984

Context: This document was prepared to provide the Virginia Department of Highways and Transportation with a framework for evaluating transit systems throughout the state.

Applicability to G-6 Project:
- [x] Performance-measurement program description(s)
- [x] Characteristics of effective performance measures or measurement systems
- [ ] Performance measure examples
- [ ] Market research
- [ ] Performance reporting
- [ ] Applications of technology

Transit Systems Evaluated: Fifteen different transit systems in Virginia

Transit Modes Considered: Urban fixed-route bus, urban demand-response (general public and specialized)

Service Contracting Addressed? No

Performance Measures Identified:
- *Transit availability:* Percent of population served
- *Comfort & convenience:* Percent of vehicles without air conditioning
- *Service delivery:* Vehicle service hours, vehicle service miles, route spacing
- *Service offered/utilization:* Total revenue passenger trips
- *Economics/productivity:* Total passenger revenue, total operating expenditures, average fare, cost per passenger mile
- *Vehicular capacity:* Passengers per seat, passengers per square foot of floor space
- *Speed & delay:* Percent of trips on time, missed trips

Summary: The first half of this report consists of a review of the transit performance measurement programs from five different states: California, Michigan, New York, Pennsylvania, and Wisconsin. Following this comprehensive summary, the authors evaluate the use of statistics and performance indicators by Virginia transit authorities. For instance, the report discusses whether Virginia transit agencies tie performance measures to specific goals and objectives. Based upon their research results, the authors present an approach intended to assist Virginia transit agencies in developing a more comprehensive performance evaluation program.

Mathias, Rosemary, and Laura Lachance

ADA Service Criteria: Measuring Compliance with Capacity Requirements for ADA Complementary Paratransit
National Urban Transit Institute, University of South Florida, Urban Transportation Research Center
U.S. Department of Transportation, Washington, D.C., 1998

Context: Study of ADA capacity requirements compliance in Florida.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☒ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: 17 Florida agencies

Transit Modes Considered: Urban demand-response (specialized)

Service Contracting Addressed? No

Performance Measures Identified:

- *Transit availability:* Missed trips, denials
- *Service delivery:* On-time performance
- *Speed & delay:* Travel time

Summary: This study of Florida ADA complementary paratransit agencies was designed to measure compliance with ADA passenger requirements. The ADA guidelines on complementary paratransit require agencies to adhere to a variety of standards that provide a comparable level of service quality. Service is supposed to be comparable to fixed-route service, while recognizing that the two types of service are different. This paper attempted to outline four measurements to determine whether capacity constraints exist. These measurements are:

- *Travel time* – Is the travel time on a one-way passenger trip the same or longer on paratransit versus fixed-route?
- *Missed trips* – What is the ratio of trips in which the paratransit trip is one or more hour late? How does that compare to fixed-route trips missed?
- *Service denials* – How many one-way trips is an agency unable to schedule? How does this compare to fixed-route service in which passengers are passed by due to a full bus?
- *On-time performance* – What percentage of trips are on time according to agency service standards? How does this percentage compare to the level of fixed-route schedule adherence?

The study finds that transit agencies do an incomplete job of collecting these data with respect to capacity.

Comments: Mathias develops a reasonable attempt for performance measures for ADA compliance. The ADA sets general performance standards for complementary paratransit service. Individuals with disabilities who are unable to use fixed-route service should have ADA paratransit that provides a level of quality and accessibility equivalent to fixed-route. These comparative measurements are designed to allow agencies to measure the compliance.

The paper found that agencies do not effectively report these data. Reporting in the area of capacity constraints often is intentionally vague so that, if there are capacity constraints, they are not readily apparent. However, capacity constraints is an area of ADA complementary paratransit in which litigation is quite common and often successful. Therefore, many agencies keep their compliance somewhat vague in the hope that this will present a more difficult target for potential litigation.

Maze, T.H.

Bus Fleet Management Principles and Techniques: Final Report
Report No. DOT-T-88-20
U.S. Department of Transportation, Washington, D.C., November 1987

Context: Monograph about improving bus fleet management

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Case study of Wichita, KS

Transit Modes Considered: Urban fixed-route bus, rural (general public and specialized)

Service Contracting Addressed? No

Performance Measures Identified: See the summary for more measures.

- *Transit availability:* Route coverage, bus stop location, vehicle hours of service, seat miles, vehicle miles
- *Comfort & convenience:* Seat availability
- *Service delivery:* Miles between road calls, on-time performance, reliability
- *Service offered/utilization:* Ridership, passenger miles, operating revenue
- *Economics/productivity:* Maintenance cost per vehicle mile, total cost per vehicle mile, fuel consumption rate, oil consumption rate, average duration of open maintenance work orders, number of open maintenance work orders, number of work orders by bus model, repeat road calls, repeat repairs, misdiagnosed repairs, percent of corrective work diagnosed during inspections, age of major components, average number of work orders processed per day, average length of time needed to accomplish a given task, average lateness of periodic inspections

Summary: The purpose of this paper is to "demonstrate methods that should permit the better management of bus fleets through the use of maintenance records and data." This task requires:

- Identifying goals and objectives
- Identifying performance measures that will achieve the goals and objectives
- Identifying information required to develop performance standards and support the collection of performance data
- Identifying points in the data flow where data are most easily collected
- Determining the most effective methods for converting data into knowledge

The author identifies the following as characteristics of good performance measures:

- *Applicability* – Measures should meet the needs of the managers who are using them.
- *Promptness* – Deviations from planned objectives should be apparent in a timely manner.
- *Critical Exceptions* – Measures should point out "critical deviations" from standards because the nature of the deviation may be more significant in some cases than in others.
- *Objectivity* – Objective measures provide consistency and accuracy.
- *Clear Definitions* – Comparisons are inappropriate unless measures are defined clearly and consistently.
- *Economy* – The value of a performance measure must exceed its collection cost.
- *Understandability* – Measures should be easily understood and should be clearly linked to what they are intended to represent.

Chapter 4 of the report focuses on the development of maintenance performance measures and includes a case study of the Metropolitan Transit Authority of Wichita, Kansas. It also includes the results of a survey in which 36 performance measures were evaluated by 92 transit maintenance managers across the county. These measures were grouped into six categories:

- *Fleet Reliabilit*y – the likelihood that the bus and its components will be operating properly; includes average miles between road calls and average age of major components
- *Fleet Maintainability* – reflects the labor and materials costs needed to repair and maintain buses; includes maintenance costs per vehicle mile, fuel and oil costs, and number of work orders per bus model
- *Fleet Availability* – the likelihood that a given number of buses will be operational at a given time; includes the average duration of open work orders and the number of open work orders
- *Work Quality* – reflects the quality of maintenance work performed; includes repeat road calls, repeat repairs, and percent of corrective work diagnosed during inspections
- *Work Productivity* – measures the amount of work accomplished in a given time period in comparison to a fixed work time standard; includes average number of work orders processed per day and average length of time needed to accomplish common tasks
- *Maintenance Control* – measures the overall performance of the maintenance department; includes performing preventive maintenance on time and the average lateness of periodic inspections

The results of the survey are summarized in the following table. Overall, the surveyed maintenance managers preferred "direct" measures (i.e., those measures that provide value independent of other measures or multiple observations) over "indirect" measures (i.e., those measures that provide value as averages or other statistics).

Value of Performance Indicators to Maintenance Managers

Category of Indicator	Performance Indicator	Most Frequent Answer*	Average Score*
Fleet Reliability	Miles per road call	Vital	4.33
	Road calls per bus per month	Very Useful	4.03
	Average age of major components on each bus model	Very Useful	3.95
Fleet Maintainability	Maintenance cost per vehicle mile	Vital	4.15
	Maintenance cost per vehicle	Vital	4.08
	Maintenance labor cost per vehicle mile	Vital	4.01
	Average fuel and oil cost per bus model vs. the total fleet	Very Useful	3.97
	Maintenance material cost per vehicle mile	Very Useful	3.95
	Maintenance labor cost per bus model vs. the total fleet	Very Useful	3.66
	Maintenance cost per bus mile per bus model vs. the total fleet	Very Useful	3.55
	Average value of parts used by each model of bus in the fleet	Very Useful	3.38
	Maintenance work orders per bus model vs. the total fleet	Very Useful	3.38
	Total value of parts used per month vs. the total value of the part inventory	Useful	3.14
	Maintenance labor cost vs. material cost	Useful	3.18
	Dollar value of parts in inventory for each bus subsystem	Useful	2.94
Fleet Availability	Current number of open maintenance work orders	Vital	3.88
	Average daily number of maintenance jobs in the backlog	Very Useful	3.36
	Average miles traveled per bus model vs. the total fleet	Very Useful	3.33
	Average duration of open work orders	Very Useful	3.20
Work Quality	Number of repeat repairs per month	Very Useful	4.25
	Number of repeat breakdowns in the same month	Very Useful	4.25
	Corrective maintenance diagnosed during p.m. inspections vs. total corrective maintenance	Very Useful	3.70
	Total labor hours spent on p.m. vs. total labor hours	Useful	3.61
Work Productivity	Total regular and overtime maintenance labor hours per month	Vital	4.25
	Average labor time taken to perform each type of p.m. inspection	Very Useful	3.80
	Estimated maintenance labor hours required to complete maintenance backlog	Very Useful	3.47
	Average daily estimate of maintenance hours backlogged	Very Useful	3.08
	Estimated labor hours to complete closed work orders (based on time standards) vs. actual hours	Very Useful	3.07
Maintenance Control	Total number of p.m. inspections scheduled per week vs. inspections actually performed	Very Useful	4.03
	Percent of p.m. inspections performed within the prescribed interval	Very Useful	4.03
	Average labor time taken to make corrective repairs	Very Useful	3.79
	Of the p.m. inspections performed past the inspection interval, the average miles past the interval	Very Useful	3.68
	Number of stock outs during the month	Very Useful	3.61
	Parts inventory value over time	Useful	3.45
	Actual labor hours to complete closed work orders vs. total labor hours	Very Useful	3.30
	Parts room overhead cost vs. value of inventory	Useful	2.68
*Scoring: 5 = Vital, 4 = Very Useful, 3 = Useful, 2 = Limited Value, 1 = Worthless			

Other measures identified during the survey are:

- road calls by system failed
- road calls by type by fleet model
- mechanical vs. non-mechanical breakdowns
- percentage of wheelchair lifts operational
- mean miles between engine and transmission failures
- percentage of air conditioning systems operable
- miles per quantity of fluids other than fuel
- maintenance labor hours per 1,000 bus miles
- number of brake relines performed per month as a percent of the fleet
- parts inventory per bus
- high cost items (e.g., tires and fluids other than fuel) per type of bus vs. the fleet
- material cost per 1,000 miles
- tire cost per 1,000 miles
- percent of active fleet waiting for repairs
- actual spare ratio vs. scheduled spare ratio
- maintenance required within 15 days of preventive inspection
- repeat repairs diagnosed and solved through preventive maintenance inspections
- breakdowns vs. number of days past preventive inspection
- number of defects reported by operators, number of defects found and corrected during preventive inspections
- percent preventive vs. corrective maintenance
- percent of total fleet cleaned daily, personnel status (available hours vs. assigned hours)
- parts on backorder and how long
- maintenance labor hours lost due to employee absence per month vs. estimated workload hours per month
- total labor hours spent on indirect labor activities vs. total labor hours
- percent of fleet without visible interior or exterior disorders (e.g., torn seats, leaks, and body damage)
- percentage of absentee labor
- percentage of labor hours that are overtime
- ratio of mechanics to buses
- percentage of overtime paid due to absences as compared to total overtime
- percentage of overtime paid to complete backlogged work orders as compared to total overtime
- average number of parts people per 50 buses
- average number of mechanics per work shift.

Still more measures are identified in the Wichita case study; the case study measures are also quantified and graphed by month.

The author also discusses the value of maintenance measures to top management (as opposed to maintenance managers), management functions, maintenance information management, data collection systems, life cycle costing, and the exchange of bus maintenance data among maintenance professionals.

Comments: The author distinguishes effectiveness into “service-effectiveness” and “cost-effectiveness.”

Note that the maintenance-oriented performance measures identified here often differ in focus and definition from those identified in other reviewed papers. “Availability,” for example, has a distinctly different meaning for maintenance managers and service planners.

McDonald Transit Associates, Inc.

Economic Benefits of Transit in Indiana: Summary Report
Indiana Transportation Association, Bloomington, IN, November 1994

Context: Study commissioned by the Indiana Transportation Association; the *Economic Benefits of Indianapolis METRO* case study (December 1994) is included in this review

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Statewide evaluation of Indiana transit systems; case study of Indianapolis

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified:

- *Community-based:* Change in employment; change in unemployment compensation; change in energy consumption; change in energy expenditures; change in non-methane hydrocarbon, carbon monoxide, and nitrous oxide emissions; air pollution costs associated with changes; vehicle accident impact; change in private auto vehicle-miles traveled; change in number of parking spaces needed; cost of constructing additional parking spaces; impacts on income taxes, sales taxes, property taxes, and other taxes; property value impact; sales impacts; total change personal travel costs; sizes of transit-dependent markets

Summary: The statewide report summarizes the economic, environmental, and social impacts of transit in Indiana. It qualitatively and quantitatively addresses transit's direct and indirect effects on employment, tax revenue, retail sales, commuting patterns, air pollution, parking supply and demand, motor vehicle accidents, and the mobility of the transit-dependent.

The Indianapolis case study is like the statewide report but provides data specifically for the Indianapolis Public Transportation Corporation (METRO) service area.

Comments: These reports will be useful to the G-6 research as they identify and quantify many community-based measures of transit performance.

Metropolitan Transit Authority of Harris County

Bus Service Evaluation Methods – A Review
Prepared for Urban Mass Transportation Administration, 1984

Context: This paper reports the results of an industry wide bus service evaluation survey performed for the METRO of Harris County in Houston, Texas.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Over 109 agencies across the country were surveyed.

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? No

Performance Measures Identified:

- *Comfort & convenience:* Bus stop spacing, passenger safety, passenger transfers, public complaints
- *Service delivery:* Route coverage, route deviation, route length, route duplication, route structures, vehicle loads, vehicle headways, schedule adherence, bus stop shelters, missed trips, span of service
- *Service offered/utilization:* Passengers per hour, passengers per mile, passengers per trip
- *Economics/productivity:* Cost recovery, cost per passenger
- *Vehicular capacity:* Vehicle loads
- *Speed & delay:* Vehicle headways, schedule adherence

Summary: There were four main objectives to this survey, to determine:

1. what performance measures were in use by transit systems across the country;
2. what service standards were in use;
3. what data are collected and at what intervals; and
4. what specific departments or individuals were responsible for collecting and analyzing performance data.

Three basic criteria were found to be in use. These were route design criteria (such as bus stop spacing, route length, etc.), service quality criteria (such as vehicle loads, headways, shelter placement, etc.), and economic and productivity criteria (such as passengers per vehicle hour, cost per passenger, etc.).

There were five types of service standards in effect. Systems that had official policies for specific performance criteria were classified as using a *formal service standard*. *Informal service standards* included systems that had specific performance objectives, but no official policy. *Proposed service standards* included systems that were in the process of developing standards or were in the proposal phase. *Criterion monitoring* and *no response* included systems that collected performance data but may not use them, or that had no measurement efforts in existence.

The survey found that 49%of all systems had bus stop spacing policies and 47% of systems had route coverage policies. Vehicle load policies were used by 63%, and 56% and 55% had headway and schedule adherence policies, respectively. Finally, 45% used passengers per hour standards and 41% used cost recovery standards. Together, 60% of the systems surveyed used route design criteria, 69% used service quality criteria, and 70% used economic/productivity criteria.

Metropolitan Transit Development Board

Agenda for Board of Directors Meeting, Items 5 and 7
Metropolitan Transit Development Board, San Diego, CA, November 15, 2001

Context: Meeting agenda attachments

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: San Diego Metropolitan Transit System (MTS)

Transit Modes Considered: Urban fixed-route bus, urban demand-response (general public and specialized), light rail, ferry

Service Contracting Addressed? Yes (MDTB Contract Services)

Performance Measures Identified: See the summary.

Summary: Item Number 5 is "MTS Operator Budget Status for the First Quarter Ended September 20, 2001." In addition to reporting budget information for a number of revenue and cost sources, key performance indicators are calculated. These indicators are:

- Energy per therm, per gallon, and per kilowatt
- Cost per revenue mile (fixed-route)
- Cost per revenue hour (paratransit)
- Revenue

Farebox recovery ratios are calculated for each operator in the MTS.

Item Number 7 is "MTS Operations Report: FY 01 Annual and Fourth Quarter Review." The indicators identified in this report are:

- Farebox recovery ratio (annual)
- Operating cost per revenue mile
- Subsidy per total passengers
- Total passengers per revenue mile

Metropolitan Transportation Authority – Long Island Bus

Information provided by Alan Erenrich, Assistant Vice-President of Policy and Planning

Context: Service guidelines obtained through a TCRP G-6 project interview

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology
- ☒ Other: Standards

Transit Systems Evaluated: MTA-Long Island Bus

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? No

Performance Measures Identified:

- *Transit availability:* Route spacing, distance to transit, service coverage, frequency, span of service, presence of passenger information modules and bus stop signs, presence of and size of bus shelters, required connections, bus stop spacing
- *Comfort & convenience:* Physical condition of revenue equipment, availability of information (e.g., timetables and maps), route directness (percent of passengers transferring and ratio of route path distance to straight-line distance)
- *Service delivery:* Passenger load, reliability (completion of assigned trips, vehicle availability percentage, and mean distance between mechanical failures), Schedule adherence)
- *Economics/productivity:* Farebox recovery, cost per passenger, passengers per vehicle hour, ridership
- *Speed & delay:* Average speed

Summary: This is a summary of MTA Long Island Bus (MSBA) information obtained from Alan Erenrich, Assistant Vice-President of Policy and Planning.

Service Coverage for Residential Trip Ends

Residences within 3/8 mile of a bus route will be considered to be served by transit. Route spacing and coverage are determined by residential density and auto ownership patterns. If density is less than 2.5 units per acre and the percent of residences without an auto is less than 2.5 percent, transit service need not be provided.

	Population Density (Dwelling Units per Acre)		
% HHs without Auto	>7.5	2.5 to 7.5	<2.5
>15%	3/8 mi	3/8 mi	1/2 mi
7.5-15%	3/8 mi	1/2 mi	1 mi
2.5-7.5%	1/2 mi	1 mi	1 mi
<2.5%	1 mi	1 mi	NA

Service Coverage for Employment/Commercial Trip Ends
Service should be provided to major activity centers according to the following criteria:

- Existing employment center with 500 persons or more per shift
- At new or emerging employment centers, 2,000 employees will be the threshold for extending a route or initiating an employee shuttle loop.
- Hospitals with 400 beds or more
- Colleges with 4,000 or more students
- Shopping centers and free-standing stores and village business districts of 200,000 square feet or larger

Frequency
Headways will be no greater than 20 minutes during weekday peak hours and no greater than 60 minutes during weekday off-peak hours. New routes will have an initial headway of 20 minutes.

Bus Loading
Service frequency should be evaluated for adjustment when passenger loads at the peak load point exceed the following loading standards.

	35-foot Bus, 40 Seats	40-foot Bus, 47 Seats
Peak Hour	125% of Load or 50	125% of Load or 59
Peak Two Hours	110% of Load or 44	110% of Load or 52
Transition	No standees	No standees
Midday	No standees	No standees
Evening	No standees	No standees
Weekend	No standees	No standees

Span of Service (Minimum)
The minimum span of service is:
- Weekday
  - Major subway feeder routes: 5 a.m. - midnight
  - Major inter-county/shopping center routes: 6 a.m. - 10 p.m.
  - Tertiary routes: 6 a.m. - 8 p.m.
- Saturday: 7 a.m. - 7 p.m.
- Sunday: 10 a.m. - 6 p.m.

Speed
Speed should average 15 miles per hour or higher.

Reliability
99.5 percent of buses should complete assigned trips. 99.8% should be the vehicle availability percentage. 2,500 miles should be the minimum mean distance between mechanical failures.

Schedule Adherence
On-time is defined as up to 4 minutes late. Early departures are not considered on-time.

Route Headway	Peak OTP	Off-Peak OTP
< 10 minutes	80%	85%
10-29 mins	85%	90%
30-59 mins	90%	90%
>= 60 mins	95%	95%

Location of Bus Shelters
The bus shelter priority guide follows.

Daily Boarding	Peak Period Headways		
Passengers	>30 minutes	16-29 minutes	15 minutes or less
>=300	1	1	1
250-299	2	2	2
200-249	2	2	3
150-199	2	3	3
100-149	3	3	3

Size of Bus Shelters
In residential areas, shelters should be no smaller than 50 square feet. In commercial areas or employment centers, shelters should be no smaller than 75 square feet.

Passenger Information Modules
At all major stops, bus schedules should be displayed.

Bus Stop Signs
Signs should indicate routes, destinations, and special information, if any.

Physical Condition of Revenue Equipment
Seats shall be clean and not loose or damaged. Floor covering shall be clean and in good repair. Light shall be operational. Heating and air conditioning systems shall be operational. Bus exteriors shall be washed every other day. Smoke, noise, and odor should be kept to a minimum through preventive maintenance procedures. Body damages should be scheduled for immediate repair. Interior and exterior graffiti shall be scheduled for immediate removal. Front and side destination signs shall be operational and used at all times. The radio and public address system shall be operational.

Public Information
Public timetables shall contain route maps, intermediate time points, fare, and transfer information. They should be available on all buses, at major interchange points, and by mail. A route map showing all bus routes, along with subway and commuter rail interchange points shall be available upon request. Bus information shall be available by phone during service hours. Either an agent or a recorded message shall be available at all times.

Fare Structure
Fare structure should have the following characteristics: equity, administrative ease, ease of comprehension, and adequate revenue-generating capacity to assure fiscal integrity. Fares should be conspicuously posted in buses at all times.

Productivity
All routes will be evaluated annually for productivity. Routes that operate at or above capacity and routes that operate significantly below capacity will be evaluated more frequently for possible adjustments. Performance indicators such as farebox recovery, cost per passenger, passenger per vehicle hour and ridership levels will be used to evaluate productivity and fiscal conditions.

Connections
Connections will be provided to the following subway terminals:

- Flushing-Main Street
- Jamaica-179th/Hillside
- Archer Avenue
- Far Rockaway-Mott Street

Connections may be provided to LIRR stations based on the following:

- Insufficient parking spaces
- Greater than 1,500 passengers using a station during the commuting period
- In high-density residential areas along well-defined corridors more than a mile from a railroad station
- If the railroad headway is less frequent than 30 minutes during commuting hours, the need for feeder bus service is less pronounced.

Connections with other local bus systems will be explored. Inter-city bus terminals in Freeport and Hempstead will be served.

Directness
No more than 30 percent of passengers should have to transfer to reach the destinations of the MSBA portion of their trips. If 20 percent or more of passengers of two separate routes transfer between the routes, consideration will be given to merging the routes. The ratio of route path distance to straight-line distance between route terminal points will not exceed 2.5.

Bus Stop Spacing and Location
A systemwide guideline for bus stop spacing is no fewer than four stops per mile. In NYC and in village centers, stops can be as close as 1/10 mile. In low density areas, stops can be spaced farther apart. Stops should be located on the far side of an intersection. At major activity centers, stops should be within 200 feet of an entrance.

All routes serve minority communities or minority populations in Nassau County. All routes that serve Queens bring reverse commuters—many of whom are minorities—from other transit services to work locations in Nassau County.

Metropolitan Transportation Authority – Long Island Rail Road

Information provided by David A. Sumner, Customer Quality and Service Planning General Manager, and Dennis C. George, Chief Engineer – Strategic Investments

Context: Service guidelines obtained through a TCRP G-6 project interview

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: MTA-Long Island Rail Road

Transit Modes Considered: Commuter rail

Service Contracting Addressed? No

Performance Measures Identified:

- *Comfort & convenience:* Announcement interval, frequency
- *Service delivery:* On-time performance, percent of scheduled cars in operation, mean miles between failure
- *Economics/productivity:* Farebox operating ratio, cost per passenger mile

Summary: This is a summary of MTA-Long Island Rail Road (LIRR) information obtained from David A. Sumner, Customer Quality and Service Planning General Manager, and Dennis C. George, Chief Engineer–Strategic Investments.

Goals and Performance Standards (1998)

An important objective of the LIRR is to provide "service which consistently delivers customers to their destinations on time." To achieve this objective, the following standards have been set:

- Passenger trains operated will arrive at terminal destinations within 5 minutes and 59 seconds of the scheduled arrival for the current timetable, 94 percent of the time.
- Except as specifically noted in the published timetables, trains will not depart early from stations where scheduled to receive customers, except at stations where an alternate train can be substituted.
- 100 percent of the a.m. peak trains operated will consist of the number of cars scheduled for that train by 1999.
- Train schedules will be planned (and, when necessary, modified) to provide sufficient time to enable them to realistically and consistently operate within on-time performance standards.
- Improvements to, or maintenance of, the Railroad's physical plant will be undertaken in a manner which will impact a minimal proportion of scheduled passenger trains.
- Passenger cars and locomotives will be maintained in an efficient and effective manner and, at least, achieve a mean-miles-between-failure rate of 36,000 miles.
- Public address announcements regarding delays, schedule deviations, car shortages, and other pertinent data will occur between 6 a.m. and 10 p.m., Monday through Friday, at a minimum interval of 6 minutes for the duration of incident. In emergencies and where feasible, announcements may be made outside these parameters.

- Changes to timetables will be advertised at least 14 days in advance of the effective date.
- Public timetables will be made available at all passenger stations a minimum of seven days prior to the effective date and throughout the effective period.
- Temporary changes to timetables to accommodate capital construction or major maintenance projects will be advertised at least seven days in advance and include alternate service provisions.
- Necessary train schedule changes required due to emergencies will be advertised within 48 to 72 hours of the occurrence through station signage and flyers. In emergencies and where feasible, announcements will be made outside of the guideline hours.
- Public address announcements and platform signage regarding train times, destination, track assignment, stops, and scheduled connections will be provided at Penn Station and Jamaica 24 hours a day. This information will be provided at Flatbush Avenue between the hours of 6 a.m. and 10 p.m.
- Achieve a farebox operating ratio of 50.6 percent.
- Achieve a cost per passenger mile of $0.31 in 1998.
- Frequency of service - The interval between train operations varies from 10 to 75 minutes during the peak and 10 to 120 minutes during off-peak periods. See the table below.

Branch	Stations	Peak Frequency		Off-peak Frequency			
				Weekdays		Weekends	
		Min	Max	Min	Max	Min	Max
Babylon	Rockville Center to Babylon	10	30	30	30	30	60
Etc.							

- Service quality: See the table below.

Branch	Standees		
	1997 Goal	1997 Actual	1998 Forecast
Babylon	790	1050	970
Etc.			

"LIRR service standards provide that seats shall be provided for all customers east of Jamaica (or flushing on the Pt. Washington branch). However, given the demand for seats between Jamaica and Penn Station as well as capacity constraints and fleet ownership, the current service standard provides for a 20 percent overload beyond seated capacity west of Jamaica."

- Daily Average Level of Service

Operating Period	Number of Trains Scheduled		
	1997 Forecast	1997 Actual	1998 Forecast
Weekday Total	740	740	740
Peak	275	275	275
Off-Peak	465	465	465
Weekend Total	510	510	448

- Revenue Car Miles in Millions

System	Revenue Car Miles in Millions		
	1997 Forecast	**1997 Actual**	**1998 Forecast**
Electric by Branch			
Systemwide	47.9	49.4	49.4
Babylon	15.3	15.1	15.1
Etc.			
Diesel by Branch			
Etc.			
East end seasonal			

Metropolitan Transportation Authority – New York City Transit

Bus Safety Performance Indicators
Office of System Safety, New York City, NY, October 1999

Context: This is an annual report on bus safety performance.

Applicability to G-6 Project:
- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: MTA-New York City Transit

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? No

Performance Measures Identified: (See the summary for more detail.)
- *Service delivery:* Number of collisions, collision rate, collision damages, number of customer accidents, customer accident rate, customer injuries

Summary: This paper contains graphs comparing 1998 and 1999 bus collision and customer accident data system-wide and by borough. It includes the following statistics:

- Total collisions by month
- Monthly collisions by division
- Monthly collision rates by division (per million miles)
- Year-to-date collision rates by division (per million miles)
- Year-to-date collision rates by month (per million miles)
- Monthly collision damages (broken down by qualitative degree of damage)
- Total customer accidents by month
- Monthly customer accidents by division
- Customer accidents by event
- Monthly customer accident rates by division (per million customers carried)
- Year-to-date customer accident rates by division (per million customers carried)
- Bus customer accidents per million customers carried (with four-year moving average)
- Customer accident injuries (broken down by treatment response)

Comments: No targets are stated.

Metropolitan Transportation Authority – New York City Transit

Local Bus Schedule Guidelines – Route Performance Indicators
NYCTA Operations Planning Department, New York City, NY, June 10, 1986

Context: Service guidelines

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology
- ☒ Other: Standards

Transit Systems Evaluated: MTA-New York City Transit

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? No

Performance Measures Identified:

- *Service delivery:* Passenger load (maximum, minimum, and average; per trip and per half-hour)
- *Economics/productivity:* Revenue per variable cost, deficit per passenger, variable cost per passenger, passengers per vehicle mile, passengers per pay hour

Summary: The objective of this document was to provide a mechanism "to relate frequency of service to actual demand in an analytical and routinized manner." The document reviewed was published in 1986 and has since been updated. The current guidelines state:

"Feeder bus routes for 40-foot buses are scheduled for up to 66 customers per bus trip during the peak hour at the maximum load point (MLP), depending on frequency, Grid routes for 40-foot buses are scheduled for up to 60 passengers per bus trip. During middays and weekends, up to 51 passengers per 40-foot bus trip are scheduled at the MLP on feeder routes. During evening and overnight service, up to 35 passengers per 40-foot bus trip are scheduled. Guidelines are also provided for the transition period between weekday peak and off-peak, as well as weekend base, and weekend evening service. Guidelines for passenger loads are also provided for routes operated with articulated buses using the same categories described above."

Metropolitan Transportation Authority – New York City Transit

"NYC Transit Committee Agenda"
MTA New York City Transit, New York City, NY, September 2001

Context: Compilation of performance and financial reports for the NYC Transit Committee; summary of Second Quarter 2001 New York City *Transit Passenger Environment Survey* document

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: MTA-New York City Transit

Transit Modes Considered: Urban fixed-route bus, urban demand-response (specialized), heavy rail

Service Contracting Addressed? Yes

Performance Measures Identified: See the tables in the summary.

Summary: This committee packet contains operational performance summaries for all NYCT modes, financial reports, summaries of procurements, summaries of service change proposals, a status report on automated fare collection, and reports on the Transit Adjudication Bureau, ADA compliance, elevator and escalator status, and First and Second Quarter service quality indicators. The two tables below describe the performance measures in this package of reports.

NYCT Operational Performance Measures (Agency Perspective)

Measure	Description/Definition	Example(s)
Terminal on-time performance (OTP) (subway)	24-hour for the system, for routes, or during the peak periods	94.5% weekday system OTP for August 2001
Thru-put (subway)		P.M. rush thru-put for August 2001 = 96.8%; A.M. rush thru-put for August 2001 = 98.9%
Mean distance between failures (MDBF) (subway)		July 2001 MDBF = 89,793 miles for car class R-28; June 2001 MDBF = 52,128 miles for car class R-28
Number of delays (subway)	By type (terminal abandonments, en-route abandonments, and late terminal arrivals) and by cause (signal trouble, switch trouble, delayed by work gang, sick customer, unruly person, no cause found, etc.)	August 2001 had 1,185 Signal Trouble delays and 362 Sick Customer delays; July 2001 had 595 Signal Trouble delays and 241 Sick Customer delays
Unavailability of cars (subway)		Staten Island Railway: 0.0% unavailable cars in June and July 2001 during the A.M. and P.M. peaks
Service reliability (Staten Island Railway)	Train trips completed as percent of train trips scheduled	Staten Island Railway: 99.9% service reliability in June and July 2001
Percent of scheduled trips completed (bus)	Percent scheduled trips completed systemwide (monthly or yearly average)	97.23% in June 2000; 98.12% in June 2001

Measure	Description/Definition	Example(s)
Percent of missed trips due to service adjustments (bus)	Percent of trips missed due to service adjustments such as the elimination of trips to maintain service regularity (monthly)	1.63% in June 2000; 1.18% in June 2001
Percent of missed trips due to operators (bus)	Percent of trips missed due to unavailable operators (monthly)	0.45% in June 2000; 0.11% in June 2001
Percent of missed trips due to miscellaneous causes (bus)	Percent of trips missed due to bus operator personal relief, sick passengers on board, criminal activity, or other miscellaneous causes (monthly)	0.03% in June 2000; 0.04% in June 2001
Percent of missed trips due to bus defects and shortage (bus)	(monthly)	0.66% in June 2000; 0.55% in June 2001
Weekday pull-out performance (bus)	Percent of required buses and operators available (by peak, yearly)	99.86% in year ending June 2001
Mean distance between service interruptions (bus)	Average distance traveled by a bus between all delays and/or inconveniences to customers (yearly)	2,155 miles in year ending June 2001
Mean distance between mechanical failures (bus)	Average distance traveled by buses between road calls attributed to mechanical problems (yearly)	2,923 miles in year ending June 2001
Trips requested (paratransit)	Excludes trips requested more than once with the initial trip resulting in a denial	231,529 in June 2001
Capacity denials (paratransit)		1,231 in June 2001
Other denials (paratransit)	Includes customers who would not accept an available alternative trip or customers who called again to request a previously denied trip	8,511 in June 2001
Early passenger cancellations (paratransit)		31,641 in June 2001
Trips scheduled (paratransit)		190,146 in June 2001
Late passenger cancellations (paratransit)	Actual number or as a percentage of trips scheduled	7,286 in June 2001
Passenger no-shows (paratransit)	Actual number or as a percentage of trips scheduled	5,345 in June 2001
Other no-shows (paratransit)	Includes no-shows on the part of the carrier	1,877 in June 2001
Completed trips (paratransit)		175,638 in June 2001
Average weekday trips (paratransit)		7,049 in June 2001
New applications received (paratransit)		2,159 in June 2001
Customer accidents and customer injuries (subway)	A customer accident involves one or more claimed injuries to a customer on the subway system (excluding assaults and suicides).	2.99 accidents per million customers carried in year ending June 2001; 3.07 injuries per million customers carried in year ending June 2001 (Goal = 2.83)
Derailments (subway and Staten Island Railway)	Incidents wherein one or more wheels of a truck/axle of a train lose their normal relationship(s) with the head of the running rail	August 2001: no derailments

Measure	Description/Definition	Example(s)
Collisions (subway and Staten Island Railway)	Incidents involving undesired/unplanned contact between single cars, between two or more passenger trains, between a light/revenue train and a work train, between two work trains, between rolling stock and bumper blocks, etc.	August 2001: one collision
Fires (subway)	Any report of fire or smoke requiring use of some type of extinguishing equipment in order to prevent property damage, personal injury, or train delay; includes train fires, station fires, ROW fires, or other fires that impact service; four severity classes	137 fires in June 2001; 106 were Low severity and 31 were Average severity; none were Above Average or High severity
Customer accidents and customer injuries (bus)	A customer accident involves one or more claimed injuries to a customer on the bus system that occurred while boarding, on board, or while alighting (excluding assaults and bus collisions).	1.00 accidents per million customers carried in year ending June 2001; 1.06 injuries per million customers carried in year ending June 2001
Collisions and collision injuries (bus)	Incidents involving a collision between a bus and another vehicle, an object, a person, or an animal	48.60 bus collisions per million miles traveled in year ending June 2001
Employee on-duty lost time accidents	Job-related incidents that result in death or the inability of an employee to perform full job duties for at least one working day beyond the day of the incident as determined by the Law department	2.66 lost time accidents per 100 employees in June 2001 (Goal = 2.56)

NYCT Service Quality Indicators (Customer Perspective)

Indicator	Description/Definition	Example(s)
Wait assessment (subway)	Measured 6 a.m. to 9 p.m. on subway; defined as the percentage of service intervals no more than the scheduled interval plus 2 minutes for peak operation or 4 minutes for off-peak operation; by system or route	Second Quarter 2001: 87.9%
Wait assessment (bus)	Measured 7 a.m. to 7 p.m. on bus; defined as the percentage of service intervals no more than the scheduled interval plus 3 minutes for peak operation or 5 minutes for off-peak operation; by system or route	Second Quarter 2001: 81.8%
Schedule adherence/ en route on-time performance	Measured 9 p.m. to 6 a.m. on subway and 7 p.m. to 7 a.m. on bus; defined as the percentage of trips departing from all scheduled en route timepoints between one minute before and five minutes after the scheduled departure time; by system or route	Second Quarter 2001: 80.4% for subway and 74.2% for bus

The packet also summarizes the results of First and Second Quarter 2001 passenger environment surveys. These surveys include 15, 17, and 24 customer-oriented indicators for subway, stations, and buses, respectively. The indicators are classified as shown in the following three tables. More can be found in the Second Quarter 2001 New York City *Transit Passenger Environment Survey* document from which the summary in the committee packet was developed. For example, the *Transit Passenger Environment Survey* document describes litter and cleanliness according to quantity, location, and nature.

Passenger Environment Survey Indicators – Subway Cars

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 percent 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 percent of fans operating when above 78° F
Operations	Percent conductors in proper uniform	

Passenger Environment Survey Indicators – Buses

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 (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

Indicator	Criteria	Description/Definition
	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 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	

Passenger Environment Survey Indicators – Stations

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 annunciator (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	

Comments: This packet contains a lot of detail beyond the lists presented above. Service reliability, for example, is broken down into tables and charts by weekday versus weekend/holiday, by type of delay, by cause of delay, by vehicle reliability (mean distance between failures), and by system rebuilding delays, with data for the current month, the previous month, the current year, and the previous year.

Few targets or goals are provided in the committee packet. Additional goals were obtained from the Second Quarter 2001 New York City Transit *Passenger Environment Survey* document.

The service changes summary provides insight into how poorly performing elements of the transit system are identified, the process by which they are modified, and the impacts of those service modifications on operations, finance, affected properties and communities, and the environment.

Metropolitan Transportation Authority – New York City Transit

Passenger Environment Survey
MTA-NYCT, New York City, Second Quarter 2001

Context: Quarterly performance report

Applicability to G-6 Project:
- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: MTA-New York City Transit

Transit Modes Considered: Urban fixed-route bus, heavy rail

Service Contracting Addressed? No

Performance Measures Identified:
- *Comfort & convenience:* See listing below

Summary: The Passenger Environment Survey (PES) is a customer-oriented set of indicators generated quarterly by Operations Planning to measure the perceptions of the customer regarding the environment in subway stations, subway cars, and buses. The PES data collection is done during weekday periods from early morning to late evening. PES indicators have been collected and reported for more than a dozen years. Changes in the PES were made over the years and recently, in 1995 and in 2000.

Subway car systemwide results are provided for the following indicators:

- Cleanliness and Appearance ("+" = surveyed throughout the day while in passenger service; "*" = surveyed throughout the day at only those terminals that have cleaners)

	+	*
Litter conditions in cars (presence of litter)		
None	46%	81%
Light	43%	16%
Moderate	2%	1%
Heavy	9%	2%
Cleanliness of car floors and seats		
None	15%	36%
Light	69%	58%
Moderate	6%	4%
Heavy	10%	2%

  - Cars with no interior graffiti: 92%
  - Cars with no exterior graffiti: 100%
  - Cars with graffiti-free windows: 98%
  - Cars with no broken or cracked windows: 99%

- Customer Information
  - Cars with all system maps correct/legible: 99%
  - Cars with all signage correct: 96%
  - Cars with public address announcements: 83%

- Functioning Equipment
  - Cars with no broken door panels: 98%
  - Lighting conditions in cars: 99%
  - Climate control conditions in cars: 97%
- Subway Car Operation
  - Conductors in proper uniform: 100%

Subway station systemwide results are provided for the following indicators:

- Cleanliness and Appearance ("+" = surveyed throughout the day while in passenger service; "*" = surveyed throughout the day at only those terminals that have cleaners)
  - Litter conditions in stations (presence of litter) + *
    - None 8% 23%
    - Light 55% 51%
    - Moderate 35% 24%
    - Heavy 2% 2%
  - Floor and Seat Cleanliness Conditions in Stations (degree of dirtiness)
    - None 3% 8%
    - Light 42% 46%
    - Moderate 47% 41%
    - Heavy 8% 5%
  - Graffiti conditions in stations
    - None: 75%
    - Light: 25%
    - Moderate: 0%
    - Heavy: 0%
- Customer Information
  - Stations with legible/correct system maps: 19%
  - Stations with correct Passenger Information Center: 78%
  - Stations with control areas with a correct subway map available: 85%
  - Station delay announcements (degree of understandability/correctness per delay occurrence)
    - Understandable/correct: 23%
    - Partially understandable/correct: 32%
    - Marginally understandable/correct: 14%
    - Not understandable/correct: 31%
- Functioning Equipment
  - Stations with functional annunciator: 98%
  - Escalators/elevators in operation: 88%
  - Station public telephones in working order: 95%
  - Station control areas that have a working booth microphone: 98%
  - Trash receptacles usable in stations: 99%
  - Working turnstiles in stations: 99%
- Station Operation
  - Token booth clerks in proper uniform: 100%
  - Token booth clerks properly displaying badges: 95%

Bus (local service) systemwide results are provided for the following indicators:

- Cleanliness and Appearance ("+" = surveyed throughout the day while in passenger service; "*" = surveyed throughout the day at only those terminals that have cleaners)
  - Litter conditions in buses (presence of litter) + *
    - None 25% 76%
    - Light 57% 20%
    - Moderate 6% 2%
    - Heavy 12% 2%
  - Exterior dirt conditions on buses (degree of dirtiness)
    - None 62% 89%
    - Light 38% 11%
    - Moderate 0% 0%
    - Heavy 0% 0%
  - Cleanliness of bus interiors (degree of dirtiness)
    - None 23% 33%
    - Light 58% 58%
    - Moderate 7% 6%
    - Heavy 12% 3%
  - Buses with no damaged panels: 99%
  - Buses with no cracked windows: 98%
  - Buses with no interior graffiti: 86%
  - Buses with no exterior graffiti: 100%
- Functioning Equipment
  - Climate control conditions in buses: 92%
  - Buses with operative kneeling feature: 100%
  - Buses with operative wheelchair lift: 97%
  - Buses with operative windows: 99%
  - Buses with operative rear door: 100%
- Bus Operation
  - Bus stops where buses board/discharge passengers appropriately: 94%
  - Bus operators in bus uniform: 100%
  - Bus operators properly displaying badges: 97%

Comments: 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 too many for a senior manager to monitor. The number of indicators could be reduced by determining the most important ones that contribute to customer satisfaction, or the indicators could be weighted and then combined into an index for each category 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 correspond the most with customer perceptions.

Metropolitan Transportation Authority – New York City Transit

Rapid Transit Route Design Guidelines and *Rapid Transit Loading Guidelines*
NYCTA Operations Planning Department, New York City, NY, February 8, 1988

Context: Service guidelines

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology
- ☒ Other: Standards

Transit Systems Evaluated: MTA-New York City Transit

Transit Modes Considered: Heavy rail

Service Contracting Addressed? No

Performance Measures Identified:

- *Comfort & convenience:* Waiting time in excess of policy interval
- *Service delivery:* Passenger load

Summary: This summary of subway route design and loading guidelines is derived from *Rapid Transit Loading Guidelines* and *Rapid Transit Route Design Guidelines* (February 8, 1988) as well as from more current information from Operations Planning.

Loading guidelines are established by taking into account the following factors: customer comfort, safety, long-standing policy, and physical limitations due to equipment and signals. Subway car size and configuration determine crush load capacity. Car size, configuration, and service guidelines which specify at least 3 square feet per standing passenger during the weekday rush influence the number and length of trains assigned to a route. During middays, weekday evenings, Saturdays, and Sundays, seats should be provided for all customers according to the recent guidelines.

The maximum interval between trains during weekday rush, midday, and Saturday is 10 minutes. The maximum interval during evening and Sundays is 12 minutes. The maximum interval during late night service is 20 minutes.

Service patterns in ascending order of level of service that are described in the 1986 document:

- Shuttle service: Trains operate on a branch line and terminate at a transfer point to a through service
- Through local service – Trains operate through to Manhattan.
- Skip-stop service – Trains operate on the same track in two patterns, A and B. Stations are designated as A, B, or AB (where both trains stop). For example, A trains would stop at A stations and AB stations, but bypass B stations.
- Express/local service – Trains operate on different tracks at two different levels of service, with "local" trains making all stops and "express" trains making express stops and bypassing the local stops.

These design guidelines are used to determine the service pattern that is appropriate for loading levels (intervals) determined by the loading guidelines. The service patterns are described in the table below. In the table, the policy interval *I* is the maximum interval scheduled at a given time. *I* is:

- 10 minutes during weekday rush hours, weekday midday, and Saturday daytime
- 12 minutes on evenings and Sundays
- 20 minutes during the owl period

Required Interval (RI) from 1986 Loading Guidelines	**Service Pattern on Main Line**	**Service Pattern on Secondary Branches of Main Line**
Case 1: Policy Interval (*I*)	Local service at policy interval	Shuttle at policy interval
Case 2: ½*I* <= RI < *I*	Express service and local service at policy interval <u>or</u> skip-stop service each at policy interval <u>or</u> local service at RI or one-half policy interval	Through service at policy interval
Case 3: RI < ½*I*	Express/local service <u>or</u> skip-stop service <u>or</u> local service at RI	Through service

In Case 1, the objective is to choose a design that provides service so that no passengers will have a waiting time in excess of the policy interval *I*. All through service should operate on the branch with heaviest ridership, while other branches should operate with shuttle service at the policy interval and with timed connections at transfer points.

In Case 2, for lines with three or four tracks, the first choice should be express and local services, unless loading is unbalanced or express stations are located poorly. For lines with two tracks, skip-stop service would probably be most appropriate, unless the savings in running time is minimal and/or there is heavy local demand. If skip-stop service is not appropriate, then local service should be considered. The differences in travel times of passengers should be the deciding factor in the service pattern.

In Case 3, if the required interval is shorter than feasible with one track, then only express/local service would be possible.

In general, during off-peak hours, for branches not near the peak load point, a seat for every passenger should be provided without exceeding the policy interval. For peak periods, the branch should be considered a separate line and the peak loading guidelines can be applied to the maximum load point (MLP) on the branch. It is important to look at system connectivity. Even if the guidelines don't require it, a more desirable service pattern may be selected if system connectivity is an issue. The following general connectivity guidelines are given:

"Passengers from any station should not require more than one transfer to reach midtown Manhattan at any time and to reach lower Manhattan during the business day; it should never require more than two transfers to get within a half-mile of any subway station south of 60th Street. The ultimate goal is to minimize total transfers and travel times, considering technical and cost constraints."

Metropolitan Transportation Authority – New York City Transit

"Reliability Indicators Used by Other Transit Agencies"
Table provided by Bob Newhouser of NYCT via e-mail, March 2002

Context: Updated review of reliability indicators used by major U.S. and selected international systems.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Atlanta, Boston, Chicago, Cleveland, Dallas, Houston, Los Angeles, Miami, New Jersey, New York City DOT, Philadelphia, San Francisco (BART and MUNI), Washington, Berlin, London, and Paris

Transit Modes Considered: Urban fixed-route bus, light rail, heavy rail, commuter rail

Service Contracting Addressed? No, except NYCDOT services.

Performance Measures Identified:

- *Service delivery:* Reliability as measured by on-time performance, schedule adherence, customer on-time percentage, excess waiting time, percent departing on time, percent of planned headways achieved, excess journey time, regularity-punctuality, and waiting time

Summary: The table below lists the reliability indicators collected by NYCT. These measures are those reported to transit agency boards, not necessarily those used to make day-to-day operating decisions.

Reliability Indicators

Agency	Measure	Mode	Definition
Atlanta-MARTA	On-time performance	Bus	0 to 5 minutes late
		Rail	30 seconds early to the lesser of 25% of headway or 3 minutes
Boston-MBTA	On-time performance	Bus, rail	0 to 5 minutes late, measured at terminals, used for scheduled headways longer than 10 minutes
	Headway adherence	Bus, rail	Service should be within 1.5 headways, measured at terminals, used for scheduled headways of 10 minutes or less
Chicago-CTA	On-time performance	Bus, rail	0 to 5 minutes late
Cleveland-GCRTA	On-time performance	Bus, rail	0 to 5 minutes late, measured at timepoints
Dallas-DART	On-time performance	Bus	0:59 early to 4:59 late, measured at prescribed timepoints
		Rail	1 minute early to 3 minutes late, measured at prescribed timepoints
Houston-METRO	On-time performance	Bus	0 to 5 minutes late, measured at prescribed timepoints
Los Angeles-MTA	On-time performance	Bus	1 minute early to 5 minutes late, measured en-route
		Rail	30 seconds early to 5 minutes late, measured en-route
Miami-MDTA	On-time performance	Bus	0 to 5 minutes late, measured en-route
		Rail	0 to 2 minutes late, measured en-route

Agency	Measure	Mode	Definition
New Jersey-NJT	On-time performance	Bus	0-5 minutes late departing Port Authority Bus Terminal in New York
		Rail	0-5 minutes late arriving at terminal
New York-NYCDOT	On-time performance	Bus	0-5 minutes late, measured at departing terminal for express, and en-route for local
Philadelphia-SEPTA	On-time performance	Bus, rail	0-5 minutes late
San Francisco-BART	Customer on-time perf.	Rail	Passenger arriving at destination 0-5 minutes late
	Train on-time perf.	Rail	Train arriving at last station 0-5 minutes late
San Francisco-MUNI	On-time performance	Bus, rail	1 minute early to 4 minutes late, measured at terminals at established intermediate points
	Headway adherence	Bus, rail	Percent of actual intervals within ±30% of the scheduled interval, or ±10 minutes, whichever is less (used for radial express, cross-town, secondary, and feeder routes)
Washington-WMATA	On-time performance	Bus	0 to 2 minutes late at any timepoint
	Headway adherence	Rail	Percent of intervals 2 minutes or more above scheduled interval
Berlin-BVG	On-time performance	Bus, rail	1 minute early to 3 minutes late, measured to nearest 30 seconds
	Reliability	Bus, rail	Percent of trips leaving monitoring point less than one interval late
London-LT	On-time performance	Bus	2 minutes early to 5 minutes, used for 4 buses per hour or less
		Rail	0 to 5 minutes late, used for 4 trains per hour or less
	Headway adherence	Bus	Difference between average actual interval and scheduled interval, used for 5 or more buses per hour
		Rail	Percent of actual intervals less than twice the scheduled interval, used for 5 or more trains per hour
Paris-RATP	On-time performance	Bus	2 minutes early to 5 minutes late, used for routes with posted schedules
	Headway adherence	Bus	For routes without public timetables, % of passengers waiting 0-2 minutes above scheduled interval; for routes with public timetables, % of passengers waiting 0-5 minutes beyond posted time
		Rail	% of intervals less than 3 minutes during peak (less than 6 minutes during off-peak)

Metropolitan Transportation Authority – New York City Transit

Service Change Procedures
NYCTA Operations Planning Department, New York City, NY, June 10, 1986

Context: Description of procedures

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology
- ☒ Other: Procedures

Transit Systems Evaluated: MTA-New York City Transit

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? No

Performance Measures Identified: See the summary.

Summary: Performance measures are used to drive service changes for buses. Service changes are categorized into minor and major changes. For major service changes, public hearings and board approval are needed. This document notes that "securing community input as a proposal is being formulated is the best way to reflect the actual needs of the community."

"Minor change" is defined as change with a magnitude that is:

- Less than 25 percent of daily revenue vehicle miles or
- Less than one hour of service span or
- Less than 25 percent of route miles

"Major change" is defined as change with a magnitude that is:

- At least 25 percent of daily revenue vehicle miles or
- At least one hour of service span or
- At least 25 percent of route miles

Frequency changes based on ridership counts may occur in the following manner:

- Minor change (decided upon by Operations Planning)
  - New schedules and Service Change Staff Summary prepared
  - Service adjustments implemented
- Major change
  - Service Change Staff Summary prepared
  - President requests and Chairman authorizes hearing
  - Public hearing conducted
  - Hearing examiner reports to President. President then proceeds.
  - MTA Board approves
  - New schedules prepared
  - Service adjustments implemented

Span of service changes are based on population density, transit dependency, institutional development, and public input in addition to ridership counts. The addition of service to a given day's operation is considered minor, while the addition of an entire day's service is considered major and experimental. In deleting service, a change is major if one hour or more of service is removed. Span of service changes may occur in the following manner:

- Minor change (decided upon by Operations Planning)
  - Service Change Staff Summary prepared
  - President approves
  - Change implemented
- Major permanent change
  - Service Change Staff Summary prepared
  - President requests, and Chairman authorizes hearing
  - Public hearing conducted
  - Hearing examiner reports to President. President recommends to MTA board
  - MTA Board Approves
  - Change implemented
- Major experimental change
  - Service Change Staff Summary prepared
  - President approves
  - MTA Board approves
  - Change implemented
  - Public hearing conducted

The following describes the steps necessary to make permanent and experimental route changes. For both types of change, the needed action items are different for major and minor changes. If the change is major, additional steps need to be taken. The additional steps for permanent changes differ slightly based on whether it is a route modification or a new route. Note that the closing of a rapid transit station entrance is considered a major permanent route change.

For permanent route changes:

- Staff recommends options with preference; discusses with affected internal and external parties
- Service Change Staff Summary prepared
- Minor change
  - President informs Board
  - Notify Board of estimate
  - Change implemented
- Major change
  - President requests and Chairman authorizes Public Hearing
  - Presentation to Community Planning Board and/or Borough President
  - Public Hearing conducted
  - Examiner reports to President after Hearing. President submits recommendation to Board for approval.
  - Modify exiting route
    - Notify Board of estimate
    - Change implemented
  - Implement new route
    - Seek Board of Estimate franchise approval
    - Seek Mayor’s approval
    - Change implemented

For experimental route changes:

- Staff recommends options with preference; discusses with affected internal and external parties
- Service Change Staff Summary prepared
- Minor change
    - President informs Board
    - Change implemented
- Major change
    - Seek Board, Board of Estimate, and Mayor approvals
    - Change implemented

Meyer, Michael D., and Eric J. Miller

Urban Transportation Planning: A Decision-Oriented Approach
Chapters 2, 3, 4, pp. 41-246
McGraw Hill, New York, NY, 2001

Context: Meyer and Miller discuss performance from the planner's perspective and describe how performance monitoring can be designed to identify where problems are likely to occur and where improvements may be made.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified:

- *Community-based:* See the summary.
- *Economics/productivity:* See the summary.
- *Speed & delay:* See the summary.

Summary: The authors, who write this book from a planning perspective, define values, goals, measures of effectiveness (MOEs), and standards as follows (p. 212):

- Values – "Basic social drives that govern human behavior. They include the desire to survive, the need to belong, the need for order, and the need for security. Because values are assumed to be shared by most groups in a culture, one can speak of societal values."
- Goals – "Generalized statements that broadly relate the physical environment to values, but for which no test for fulfillment can be readily applied"
- Objective – "Specific and measurable statements that relate to the attainment of goals"
- MOEs – "Measures or tests that reflect the degree of attainment of particular objectives in the context of plan or project evaluation"
- Standards – "Minimum acceptable level for the criterion measure"

The authors describe the desired characteristics of goals and objectives:

- "Goals and objectives must be clear, concise, unambiguous, and understandable to all actor groups.
- Objectives must logically follow from applicable goals.
- Goals and objectives must reflect the views, perceptions, and aspirations of the community.
- Each objective must be measurable by at least one MOE.
- The MOEs must be measurable with reasonable effort.
- Goals and objectives must be developed independent of specific transportation plans and not be mode specific."

In Table 4.14 in the report, pp. 214-15, the authors provide the following example:

Goal: Transit service must provide mobility options for major transit markets in the county.

Objective: Provide transit services that are accessible to those with limited mobility.

MOE: Degree to which limited mobility populations live within transit area.

(Performance Measures: Would fit here in the authors' framework)

Characteristics of diagnostic measures are as follows:

- "The required data must be collected on a periodic basis to allow updating of the problem identification process.
- Many measures are related to one another, meaning surrogates can be used to identify closely related problems.
- Standards used to identify the level of system or facility performance above (or below) which the performance is considered problematic must be carefully defined to relate to the problems being faced by the organization or community.
- Diagnostic measures should be related to the planning and agency objectives.
- Diagnostic measures only identify where problem areas exist; they do not indicate what types of corrective actions might be required."

Characteristics of Performance-based Planning are as follows:

- "System performance linked to fundamental roles of transportation" – Measures should be related to what role transportation plays in a region.
- "Outcomes as well as outputs" – It is important to distinguish outcomes and outputs. Outputs are such things as number of revenue vehicle miles. Outcomes "relate to the ultimate effect of the transportation system on a community, such as quality of life, environmental health…"
- "Mobility and accessibility" – Mobility and accessibility are essential goals for transportation planning. Distributional effects should not be ignored when considering these goals.
- "Multimodal performance measures" – PMs should be multimodal, not mode-based. The total trip perspective should be kept in mind. This concept echoes the NTS report.
- "Performance measures tied to project evaluation criteria" – Decisions makers should use performance measures (PMs) to select transportation projects. For example, if job creation is an important outcome/goal for a community, then the evaluation of the project alternatives should have a similar criterion.
- "Strategic data collection and management plan" – Availability of data can foretell the success of performance measurement.

The following are characteristics of effective performance measures:

- Measurability – Data and analysis tools must be available to generate valid results.
- Pertinence – Performance measures should reflect the policies or objectives for which they were developed.
- Clarity – PMs should be easily understood by planners and decision makers.
- Sensitivity and responsiveness – PMs must be able to detect changes in system performance.
- Appropriate level of detail – PMs must be specified at a level of detail appropriate to their intended use.
- Insensitivity to exogenous factors – PMs should not be influenced by non-transportation events. (T*his directly contradicts the characteristics of many outcome measures, which are influenced by non-transportation events.*)
- Comprehensiveness – Degree to which PMs can measure across all market segments and locations
- Discrimination between influences – Degree to which individual components affecting system performance can be differentiated

Miller, James

Shared-ride Paratransit Performance Evaluation Guide
Urban Mass Transportation Administration, Washington, D.C., 1989

Context: The guide was written to allow paratransit managers to develop performance procedures.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☒ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: Urban and rural demand-response (general public and specialized)

Service Contracting Addressed? No

Performance Measures Identified:

- *Service delivery:* Accidents per 100,000 miles, complaints, on time performance
- *Service offered/utilization:* Ridership, revenue hours
- *Economics/productivity:* Trips per mile, passenger miles per hour, cost per passenger, cost per hours

Summary: The goal of this manual was to provide a method for a paratransit manager to develop measurable performance procedures. Miller views this as essential in responding to funding agencies and officials. Five key reasons to evaluate are:

- Control costs
- Justify service change levels
- Monitor the subcontractor
- Guide marketing efforts
- Ensure financial integrity

All five of Miller's explanations are internally oriented. He focuses upon what the organization needs to perform well. There is no mention of customer satisfaction in performance evaluation. Nevertheless, quality issues are recognized as significant. Complaints, on time performance, and preventable accidents are all cited as significant evaluation measures.

Comments: The evaluation framework is designed to be applicable to a wide range of paratransit environments including private shared-ride service, human services transportation, and specialized transit systems. Applicability is designed for urban and rural settings.

Miller, James H.

"The Use of Performance-Based Methodologies for the Allocation of Transit Operating Funds"
Traffic Quarterly, Vol. 34, No. 4, pp. 555-574
Eno Foundation for Transportation, Inc., Westport, CT, October, 1980

Context: Miller presents various approaches taken by funding agencies in the use of performance measures to allocate transit funds.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None, though some are cited

Transit Modes Considered: All

Service Contracting Addressed? Yes

Performance Measures Identified: (p. 561)

- *Comfort & convenience:* See the summary.
- *Service delivery:* See the summary.
- *Service offered/utilization:* See the summary.
- *Economics/productivity:* See the summary.

Summary: Historical background on the use of performance measures (PMs) for resource allocation is provided. Miller mentions that Fielding and Glauthier developed an allocation method for California and that they used data availability, inherent bias, and methodological correctness as criteria for selecting PMs. For instance, measurements involving service area population may be inherently biased if there is no consistent way to determine service area. Miller cites Pennsylvania, New Jersey, and New York as states that have begun to develop or have implemented performance-based funding.

Another researcher mentioned is Drosdat, who uses:

- "Aggregate significance - Are the measures useful in evaluating the overall system as opposed to individual routes?
- Ease of definability - What is meant by 'population served?'
- The validity of the measure - For example, measurement of a system's average number of transfers says little about performance because of differences of regional geography and local settlement patterns."

According to Miller, critical issues that influence the selection of PMs are:

- The goals and objectives to be achieved
- Acceptance of the measures by transit officials
- The inadequacy of transit efficiency measures
- The way transit performance influences transit aid funding

In fund allocation, the two primary approaches to the application of PMs are:

1. Establishment of minimum standards for each PM - All, or part, of a transit system's grant would be based on "yes-no" tests for the measure
2. Ranking transit systems on the basis of a scoring method derived by summing weighted values of each criterion

In addition, Miller provides the following guidelines for a new PM framework for fund allocation:

1. The PMs must be related both to societal goals for transit and to the legislative goals of the funding program.
2. To be workable, the system of measure must be very simple.
3. The funding agency must view the transit property and the local government as a single policy-making unit.
4. Data to measure each variable must be readily available and unambiguous. *(Note that this fourth criterion contradicts the recommendations made by the NTS report to avoid selection of PMs based on data-related criteria.)*

MORPACE International, Inc. and Cambridge Systematics, Inc.

"A Handbook for Measuring Customer Satisfaction and Service Quality"
TCRP Report 47
National Academy Press, Washington, DC, 1999.
http://nationalacademies.org/trb/publications/tcrp/tcrp_rpt_47-a.pdf

Context: A guide for developing, monitoring, and applying an ongoing customer satisfaction program.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☒ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Chicago Transit Authority; SunTran (Albuquerque, NM); Lynchburg, VA

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified:

- *Community-based:* See the summary.
- *Transit availability:* See the summary.
- *Comfort & convenience:* See the summary.
- *Speed & delay:* See the summary.

Summary: TCRP Report 47 provides a wealth of information on developing a performance-measurement program that measures customer satisfaction. The report presents techniques for developing and conducting customer satisfaction surveys, which serve two main purposes: (1) identifying the service quality factors that have the greatest influence on a particular system's customer satisfaction, and (2) tracking aspects of service quality over time that are difficult to measure using traditional performance measures.

An "impact score" approach is explained that helps agencies identify key service quality factors. Under this approach, satisfaction ratings are determined for each factor being surveyed. The responses are divided into two groups: one consisting of people who experienced a problem with that factor during the previous 30 days, and the other consisting of people who did not experience a problem. An average rating for each factor for each group is calculated, along with a "gap score", which is the difference in the two groups' ratings for a particular factor. For example, if satisfaction was being measured on a 1-10 scale, with 10 being the best, and the no-problem group had an average rating of 8 and the had-a-problem group had an average rating of 6, the gap score would be 2. A gap score of 0 indicates that even if a problem occurs, it does not affect customer satisfaction. The greater the gap score, the greater the impact on customer satisfaction when a problem occurs.

To help prioritize actions to improve service quality, an impact score is developed for each factor, which is the factor's gap score multiplied by the percentage of people who experienced a problem with that factor. The higher the impact score, the greater that factor's impact on customer satisfaction—the problems that customers find serious, and also affect a large number of customers, will end up at the top; problems that are serious, but happen rarely, or are relatively widespread, but not considered serious by customers will have a lower priority; and non-serious problems that occur rarely will have the lowest priority. Gap scores should not change significantly over time. However, impact scores will change as the number of people affected change over time and, as a result, impact scores are a useful tool for tracking changes in customer satisfaction over time for various factors.

Once key customer-satisfaction factors are identified (both those that currently have problems and those that would significantly impact customer satisfaction if they became problems), an agency can develop a program to address and monitor those factors. The monitoring program could include a combination of performance measures (e.g., tracking reliability, if “buses that arrive on schedule” was important), inspection programs (e.g., passenger environment surveys, if “bus/train cleanliness” was important), follow-up surveys (for measures hard to track by other means), and potentially other techniques.

The extensive report appendices provide an example customer satisfaction survey and sampling plan, examples of potential service quality attributes to survey, a summary of customer satisfaction factors routinely tracked by agencies, and an annotated bibliography on customer satisfaction.

The project tested the procedures by conducting customer satisfaction surveys in Chicago, Albuquerque, and Lynchburg, VA. A total of 46 service quality factors were surveyed, which can be grouped into the following nine categories: comfort, nuisances, scheduling, fares, cleanliness, in-person information, passive information, safety, and transfers. The top categories that were existing problems were scheduling, followed by comfort and nuisances (e.g., unruly passengers). However, when potential problems were analyzed, fares and scheduling were the top concern, followed by comfort and safety, with nuisances the category with the least potential for high levels of concern.

Comments: The Center for Urban Transportation Research conducted customer satisfaction surveys for the Florida Department of Transportation in 1997. These surveys covered 22 factors. Existing problems of greatest significance to Florida customers were hours of service, routes, and headways. Potential problems of greatest significance were routes and headways, hours of service, bus ride comfort, printed schedules, and safety and cleanliness.

Multisystems, Inc.

VIAtrans Supply Model Final Report
Prepared for VIA Metropolitan Transit, San Antonio, TX, December 2000

Context: This study was designed to indicate for VIA Metropolitan Transit's ADA complementary paratransit program how various changes in service performance or service standards might affect service demand.

Applicability to G-6 Project:
- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology
- ☒ Other: Case Study - VIA, San Antonio

Transit Systems Evaluated: VIA Metropolitan Transit

Transit Modes Considered: Urban demand-response (specialized)

Service Contracting Addressed? Yes

Performance Measures Identified:
- *Transit availability:* Same day trips
- *Comfort & convenience:* On-time performance
- *Service delivery:* Service denials, transfers

Summary: This study is not a discussion of performance measures, but rather indicates the impact that improving or reducing service quality may have on demand. Since transit agencies are operating in an environment of significant financial limitations, increasing service quality and performing better may result in increased demand that may not lead to future improvements in quality due to resource constraints.

Increasing fares for ADA paratransit is allowable up to twice the cost of regular fixed-route service. Fare elasticity for paratransit fares was approximately -0.175. In other words, a 10 percent increase in paratransit fares would result in a 1.75 percent decrease in paratransit demand. Increasing the service cost from the point of view of accessibility may be negative but it may increase resources available for other trips and enhance service quality. Allowing same-day trips would dramatically improve trip accessibility and could result in an increase in demand of up to 40 percent. Again, improved quality in this environment of limited resources can result in a deterioration of quality elsewhere.

Comments: This study is included because it indicates that providing improved quality service in one aspect of service may not result in improved quality because it may impact demand. If an improvement in quality results in higher demand, which then results in an agency having inadequate resources to meet the higher demand, it may ultimately result in lower service quality. For example: On-time performance is improved from 93 percent to 98 percent by reducing the scheduling system speed by 5 percent. Service productivity declines by 5 percent since fewer trips are provided. Denials increase by 50 percent because capacity is now used for fewer trips. The alternative to maintaining quality is increasing available capacity by 5 percent to meet the slower system speed. However, demand increases by 5 percent and service capacity must be increased by 5 percent. The result is that improving system speed resulted in either a decline in other quality performance standards or a drastic increase in cost that must be met by adding additional resources. Many transit agencies do not have the resources. Should they maintain poor service quality because that is all that they can afford?

Multisystems, Inc.

Washington Metropolitan Area Regional Bus Study: Comprehensive Operations Analysis Summary Report
Washington, D.C., 2000

Context: Consultant report assessing WMATA's bus service performance.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☒ Applications of technology

Transit Systems Evaluated: WMATA (Washington, DC)

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? No

Performance Measures Identified:

- *Transit availability:* Service coverage, span of service, frequency of service
- *Comfort & convenience:* Travel time, load factor, reliability
- *Economics/productivity:* Boardings per vehicle revenue hour (non-express routes), boardings per trip (express routes)

Summary: This report presents an evaluation of the existing condition of WMATA bus services, relative to agency goals. The report is an interim product in a project that is intended to identify bus service improvements in the Washington area.

Most of the performance measures evaluated are based upon the service measures presented in the *Transit Capacity and Quality of Service Manual*. As an alternative to using the levels of service given in the TCQSM, numeric standards were set for each measure, and performance was evaluated based on the percentage of routes or system area that met the standard. The following are the specific passenger-oriented standards used in the report:

- Service coverage: in areas with 3 households per acre or more, 90% of households within ¼ mile of a bus route; in areas with 2-3 households per acre, 80% of households within ¼ mile of a bus route; areas with at least 4 jobs per acre, including specific activity centers, should be served

- Service frequency: at least every 15 minutes in dense areas (more frequent if demand warrants), 30 minutes peak and 60 minutes off-peak in less-dense areas

- Travel time: express routes—no more than 150% of the auto travel time, non-express routes—no more than twice the auto travel time

- Load factor: off-peak (all service types)—1.0, peak express with premium fare—1.0, peak urban crosstown—1.1, all other peak services—1.2

The following table lists the productivity standards used in the report:

Service Type	Measure	Weekday Peak	Weekday Average	Off-Peak
Radial line-haul	Boardings/VRH	30	24	18
Urban bus, >= 30 ft	Boardings/VRH	30	24	18
Suburban bus, >=30 ft	Boardings/VRH	15	12.5	10
Express bus	Boardings/trip	23	23	23
All classes, bus <30 ft	Boardings/VRH	12	11	10

VRH: vehicle revenue hour

GIS software was used to calculate service coverage area, and compare this area to the areas that had sufficient population and job density to apply the service coverage standards. Population and job data were obtained from the Metropolitan Washington Council of Governments. Maps were produced comparing service coverage to higher-density residential and employment areas.

Multisystems, Inc., and Craig & Associates, Inc.

Evaluating Transit Operations for Individuals with Disabilities
TCRP Web Document 2
Transportation Research Board, Washington, D.C., January 1997

Context: A survey of 548 public transit systems in the United States and Canada to identify agencies that have developed and implemented innovative service programs in an effort to provide more cost-effective transportation to persons with disabilities. Included in the report are a discussion of performance measurement programs for measuring innovative service delivery methods and enhancements developed to facilitate the use of fixed-route transit services by customers with disabilities.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: 548 public transit systems in the United States and Canada

Transit Modes Considered: Urban demand-response (specialized)

Service Contracting Addressed? No

Performance Measures Identified:

- *Community-based:* Measures broader benefits to the general public, including the impacts on the overall mobility of paratransit customers
- *Transit availability:* Measures service options and enhancements according to the degree to which they increase the ability of paratransit patrons to access fixed-route buses
- *Comfort & convenience:* Measures satisfaction of riders with each type of service option and enhancement
- *Service delivery:* Measures degree to which innovative service options and enhancements promote overall system integration in terms of facilitating smooth transfers and accessibility of paratransit customers on fixed-route buses
- *Service offered/utilization:* Measures increases in ridership of fixed-route buses by paratransit customers
- *Economics/productivity:* Measures savings accrued to transit agencies from shifts in usage of fixed-route services by paratransit customers as a results of different added service options and enhancements; includes savings generated from reduced operating costs

Summary: A survey of 548 public transit systems in the United States and Canada was conducted as part of a research project aimed at identifying public transit agencies that have developed and implemented innovation service programs in an effort to provide more cost-effective transportation to persons with disabilities. Chapter VII, “Effectiveness and Applicability of the Options and Enhancements Studied,” looks at some innovative quantitative and qualitative measures of effectiveness. The study applies these measures to service options/enhancements that are designed to encourage the use of fixed-route buses by paratransit patrons. Options/enhancements measured include service routes, feeder service, route deviation, low-floor buses, and the use of fare incentives. These are measured to the degree that they provide for customer integration, overall system integration, number of trips shifted from paratransit to fixed-route, net cost savings, community acceptance, and related benefits/issues.

Customer integration measures the degree to which the service option promotes integration of riders with disabilities with the general public. System integration refers to the degree of integration between paratransit and fixed-route service that is created by the option. Trips shifted refer to the total number of trips shifted from paratransit trips to the combined service option. Net cost savings considers the cost associated with implementation and ongoing operation as well as savings generated from reduced operating costs. Community acceptance measures the satisfaction of riders with the service options and enhancements. Issues raised by customers, advocates, and local officials concerning changes in travel time, quality of service, and general level of service are considered. Related benefits include other quantitative and qualitative benefits or issues not captured by the above measures. One example includes the savings that may accrue to other agencies as a result of the service options and enhancements.

Mundy, Ray A.

"Mass Transit Guidelines Versus a Consumer Orientation in Public Transportation Systems"
Transportation Research Record 625
National Academy Press, Washington, DC, 1977

Context: Discussion and evaluation

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☒ Market research
- ☐ Performance reporting
- ☐ Applications of technology
- ☒ Other: Research

Transit Systems Evaluated: None

Transit Modes Considered: All (generally)

Service Contracting Addressed? No

Performance Measures Identified:

- *Transit availability:* Frequency (headways), density of the route network
- *Comfort & convenience:* Safety, cost, convenience, comfort, information
- *Service delivery:* Reliability, seating capacity, mobility
- *Economics/productivity:* Energy conservation, pollution control
- *Speed & delay:* Time savings

Summary: This paper summarizes the factors that influence mode choice and evaluates mass transit guidelines that contain level of service criteria. A broader definition of transit service alternatives (and level of service within these alternatives) is necessary to develop urban public transportation systems that meet consumer needs and desires.

Comments: Note that paper and the guidelines and research reviewed were written in the 1970s.

Nakanishi, Yuko J.

"Bus Performance Indicators: On-Time Performance and Service Regularity"
Transportation Research Record 1571
National Academy Press, Washington, D.C., 1997

Context: The author discusses on-time performance (OTP) and service regularity, the bus reliability performance indicators that were developed as a NYC Transit initiative to assess reliability of bus service from the customer's point of view.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: MTA-NYC Transit

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? No

Performance Measures Identified:

- *Community-based:* Customer-oriented reliability
- *Service delivery:* Reliability

Summary: The author discusses the customer-oriented bus performance indicator program (PIP) established at NYC Transit and provides details about the schedule adherence indicators of en route OTP and service regularity indicators included in the program. The bus PIP measures the weekday performance of the most heavily traveled routes in each borough. Although the measures are useful as diagnostic tools, the primary purpose of the program represents the reliability of transit service experienced by customers, using the two objective measures. The author states that "good reliability indicator programs will contain key measures that are clear, understandable, and useful to the customer and will maintain consistent analysis methodology across reporting periods and across all routes in the transit system."

For OTP, *en route departures* were surveyed because (a) en route locations serve more customers than terminal locations and (b) lengthy dwell times can cause a significant gap between arrival and departure times. A measure of service regularity is also necessary because, as noted by the author, on-time performance becomes less vital to the customer when service is frequent.

The two indicators, en route OTP and service regularity, and data issues are described in detail and will be included in the PM assessment.

Comments: NYC Transit has replaced the service regularity indicator with a new wait assessment measure. The new measure rates scheduled waiting times by a fixed standard rather than the proportional standard. It is more stringent for subways versus buses and for peak hours versus off-peak hours.

Nakanishi, Yuko J., and G.F. List

Regional Transit Performance Indicators: A Performance Measurement Model
Rensselaer Polytechnic Institute, Troy, NY, 2000

Context: The transit customer in many metropolitan areas may utilize more than one system when making a trip. However, performance is reported by agency and rarely on a regional basis. The authors propose the creation of a regional transit performance indicator program, discuss the steps involved in implementing it, and present ways in which performance may be reported from the customer's point of view.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified: None

Summary: In many metropolitan areas, more than one agency operates transit service. Travelers must transfer from one transit system to another, crossing agency and jurisdictional boundaries. Therefore, the authors recommend reporting regional transit performance. Currently, some MPOs such as the New York Metropolitan Transportation Council attempt to aggregate performance data and report performance on a regional basis. However, with different agencies utilizing disparate data sampling, collection, and analysis methodologies, aggregating performance statistics is difficult. Implementing the performance indicator program (PIP) proposed by the authors requires the following steps:

1. Determination of Regional Goals
2. The Generation of All Possible Indicators for Each Goal
3. Selection of Ideal Indicators for Each Goal
4. Creation of Indices
5. Determination of Data Requirements (sampling, collection, and analysis)
6. Determination of Costs and Revision of the PIP if necessary
7. Pilot Testing of the PIP
8. Revision of the PIP, if needed
9. Implementation of the PIP

Once the PIP has been implemented, the performance reporting and PIP revisions need to be continuous. The authors provide a Regional Performance Indicator Program Reporting and Analysis Flowchart consisting of the following activities:

1. Performance Results are Reported
2. A Gap Analysis (Targeted versus Actual) is Conducted
3. Agencies Formulate an Improvement Strategy
4. A Regional Improvement Strategy is Established
5. The Indicators and Performance Targets are Reviewed and Revised Periodically

These activities are cycled through on a continuous basis.

According to the authors, the characteristics of an effective performance measurement system are as follows:

- *Accepted by and credible to decision makers* – A performance measurement program that is not accepted by and credible to decision makers will be ignored and eventually fail. Ideally, senior management should take the lead in developing and promoting it, giving the program visibility and status within the organization.
- *Accepted by Agency Managers and Operational Employees* – Because performance measures reflect the output of multiple individuals, they should not be created by a few individuals. Instead, operational staff should have a chance to participate in the development process; the senior management of each agency should hold special workshops for their employees, informing them about the PIP and obtaining their opinions regarding the indicators. If agency staff at all levels of the organization have a chance to participate in developing the measures, they will be more willing to "buy-in" to the measurement system and will be more attuned to PIP results and motivated to participate in the achievement of the regional goals.
- *Clear and easily comprehensible* – Acceptance by transit agencies and stakeholders will be facilitated if the indices are easy to understand and the links between indices and goals are evident. Also, a system of measures that is excessively complex will have difficulty meeting its objectives of improving transit service or identifying trends and problems.
- *Linked to the factors needed to achieve regional transit goals* – The factors that are significant in reaching regional goals must be identified and represented by the performance indicators and indices. Indicators and indices should be able to show changes in performance that, in turn, should reflect changes in goal attainment.
- *Objective and free from bias* – For performance measurement systems to succeed, those involved in developing the indicators, obtaining data, and analyzing it must not permit their interests to affect the accuracy of the results. The person(s) responsible for performance reporting for a particular indicator should ideally be from a division that is not connected with that indicator, so that the possibility of bias is eliminated.
- *Combinations of past, present, and future-oriented indicators* – Some indicators inform about what has happened in the past (for example, the average number of transit riders per month for the past six months). Other indicators describe what is currently happening (for example, the number of riders for the current month). Still other indicators "predict" what may occur (for example, if the satisfaction level of riders has declined, the number of riders may decline in the next several months or so). The inclusion of lagging, current, and leading types of measures in the PIP will create a "balanced" scorecard method of performance measurement.
- *Fewer rather than many* – When the number of metrics becomes too high, agency management and employees and others begin to ignore many of them and the focus on performance measurement is lost. If measures are limited to a small number, they will be able to concentrate on the vital measures. Hence, a benefit of utilizing indices is their ability to incorporate many indicators, while the actual number of indices can be minimized.
- *Flexibility to allow additions and changes as environmental or strategic changes occur* – Goals change periodically, as do external factors. Hence, the performance measurement model should be flexible and permit change. The flowchart shown in Figure 2 in the paper incorporates regular re-examination of performance measures.
- *Realistic with respect to targets and goals* – Targets should be realistic. A target that is too high, such as a transfer rate of hundred percent for on-time performance in a congested area, could simply be ignored. The goal should be slightly out of reach; this would encourage managers and employees to strive harder to reach the goal.

- *Communicated to agencies, stakeholders and the public on a timely basis* – Timeliness of performance reporting is important. If the dissemination of results is delayed, performance may have changed and the results may no longer be current. Also, any delay in performance reporting will cause delays in problem identification and service improvement.
- *Motivational without threat of discipline or punishment* – The performance measurement system should be able to motivate employees without the threat of discipline or the enticement of rewards, especially if the results are publicly posted throughout agencies on a consistent basis. In many cases, there is not absolute correlation between accomplishments and the indicator and it would be unfair to discipline based on such indicators.

Nakanishi, Yuko J., G. List, and M. Martinez

The Hidden Costs of Station Renovations: The Transit Customer's Perspective
RPI Working Paper, Troy, NY, 2000

Context: The paper develops an impact assessment methodology to identify the impacts of station renovations on passengers; also mentioned are ways in which negative impacts might be mitigated.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: MTA-NYC Transit

Transit Modes Considered: Heavy rail

Service Contracting Addressed? No

Performance Measures Identified:

- *Comfort & convenience:* Customer survey, customer-impact index
- *Speed & delay:* Pedestrian movement/flows

Summary: The authors propose a methodology to assess the impacts of transit station renovations on customers. The method involves the following steps:

1. Identify key attributes of importance to customers and that might be affected by construction.
2. Develop the survey to evaluate customer perceptions of the impact on the selected attributes.
3. Perform survey and observations.
4. Perform statistical analysis.
5. Create customer impact index.

The authors chose the Broadway Line Platforms of the Times Square Station to test the methodology. For the survey, customers were asked to rate the degree of change from pre-construction to construction for each factor: safety, security, convenience, distance, and time. The factors were described as follows:

- Safety – protection from harm due to train operations
- Security – protection from criminals and unruly or menacing individuals
- Convenience – for boarding passengers, the ease of accessing the platform except for distance and time; for alighting passengers, the ease of accessing other platforms or exits except for distance and time
- Distance – perceived distance from the platform to the transfer area or from the transfer area to the platform
- Time – perceived time from the platform to the transfer area or from the transfer area to the platform

Statistical tests were done to determine the overall impact for each factor and whether there was any difference in perception between males and females, between business and leisure travelers, between peak and off-peak customers, and among various age groups. The customer impact index was created by identifying (1) the length of the construction period, (2) the number of passengers affected, and (3) survey results (degree of impact perceived by customers). The index provides an indication of the degree to which each factor affects customers during the station renovation.

Recommendations for making customer-related improvements at the Times Square Station complex were made based on the customer impact index results, the customer survey, and observations of conditions at the station.

Comments: The contracting issues mentioned briefly in the paper relates to the usefulness of the customer impact index in determining rewards or penalties for contractors who create impacts on customers (e.g., delays in completing construction).

Nakanishi, Yuko J., and Robert Paaswell

Transit Performance Measurements Projects with the Straphangers Campaign: Report to the Sloan Foundation
Region 2 UTRC, New York, NY, 1997

Context: The primary objective of the project described in this report was to provide the public with a clear, comprehensive, and ongoing profile of subway service.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: MTA-NYC Transit

Transit Modes Considered: Heavy rail

Service Contracting Addressed? No

Performance Measures Identified:

- Comfort & convenience: See the summary.
- Service delivery: See the summary.
- Service offered/utilization: See the summary.
- Speed & delay: See the summary.

Summary: Selected performance measures for NYC Transit's subway lines are reported by the Straphangers Campaign on an annual basis. The performance measures were selected based on a focus group of transit customers and experts, as well as on what data were readily available from NYC Transit. The selected measures were: cleanliness, chance of getting a seat, amount of scheduled service, regularity of service, breakdown rates, and in-car announcements. (Note that data availability decreased the population of performance measures from which the measures could be selected.) After the measures were chosen, the focus group assigned weights to each measure. Once the composite performance results are obtained, the scores were converted into a dollar value. For instance, the 1 & 9 line received a dollar value of 80 cents (out of a maximum possible score of $1.50, the cost of a one-way subway trip).

The Straphangers Campaign used easy-to-comprehend language in its reports. For example, in addition to a graph showing "average miles traveled between delays caused by mechanical failures," the report states that "the 1 & 9 line breaks down less often than the average line," and, in addition to showing the "% of passengers with seats at most crowded point during rush hour", it states that "you're less likely to get a seat on the 1 & 9." The report contains visually appealing graphics and is, in essence, user-friendly.

The authors describe the selected measures as follows:

- *Scheduled Service* – Headways were measured for the weekday morning rush, afternoon rush, and midday hours, with morning and afternoon rush each contributing 40 percent and the midday contributing 20 percent to the scheduled service indicator. Because virtually all subway lines operate at the same interval (20 minutes) during late night hours, overnight headways were not included in the analysis.
- *Service Regularity* – Service regularity, measured between 6 a.m. and 9 p.m. on weekdays, is defined by NYC Transit as "the percentage of intervals between two trains trips departing from all scheduled time points, not including terminals, that are within plus or minus 50 percent of the

scheduled interval (for all intervals less than ten minutes) or within plus or minus 5 minutes of the scheduled interval (for intervals of ten minutes or more)."

- *Mechanical Failures* – MDBF, or Mean Distance Between Failures, is defined by NYC Transit as the total number of revenue miles divided by the total number of mechanical failures resulting in delays.
- *Chance of Getting a Seat* – The calculation of this measure involved isolating the most crowded 15-minute interval for each line for the most crowded point and dividing the total number of seats by the number of passengers during that interval.
- *Interior Cleanliness* – The Passenger Environment Survey (PES) conducted by NYC Transit on a quarterly basis generates information about the transit environment experienced by transit customers. One of the indicators generated by the survey measures cleanliness inside subway cars. For this project, 'light degree of dirtiness' and 'none' constitute cleanliness. "Light" degree of dirt is defined as "occasional 'ground in' spots, but generally clean."
- *In-Car Announcements* – In-car announcement is also one of the indicators generated by NYC Transit's PES. Announcements are adequate if they are "understandable" and "correct." These announcements include: next station, transfer options, route designation, route destination, and "stand clear of the closing doors" announcements.

Comments: A major constraint in this project appears to be data availability. Other customer-oriented and more "ideal" measures may have existed, but the selection process considered data availability and, hence, ruled out many measures.

Navari, Sachin R.

"Accounting for Temporal and Spatial Distribution in Transit Accessibility"
Presented at the APTA 2001 Intermodal Operations Planning Workshop, Cleveland, OH, August 5-8, 2001

Context: Conference presentation on a measure of the number of weekly trip ends for which transit service is available.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology
- ☒ Other: Calculation method and tool

Transit Systems Evaluated: Tampa, FL

Transit Modes Considered: Applicable to any fixed-route service

Service Contracting Addressed? No

Performance Measures Identified:

- *Transit availability:* Transit service availability index (total daily trips exposed to transit service)

Summary: This presentation describes a performance measure developed by researchers at the Center for Urban Transportation Research that 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. Travel demand in this spreadsheet is a function of population, employment, and trip generation. CUTR has developed a spreadsheet to assist in calculating the measure; this spreadsheet provides default demand data taken from the 1995 Nationwide Personal Transportation Survey (NPTS). GIS software will also be required to determine the percentage of a zone's trip generation that can access a particular transit route.

Calculating the transit service availability index is a four-step process in the spreadsheet:

1. *Temporal allocation*—Default temporal demand data (% of daily trips occurring each hour) can be used based on the 1995 NPTS, or users can supply data specific to their area.
2. *Service supply*—Users enter service data for each route, including the route's start and end times (or headways), and a maximum desired passenger wait time at a transit stop.
3. *Geographical route coverage*—For each route, users enter the percentage of each zone's trip generation that can access that route.
4. *Index calculation*—Users enter each zone's population and employment, and a relative trip generation weight for weekdays, Saturdays, and Sundays.

The total daily trips in a given zone exposed to transit service is based on the sum of the daily trips exposed in each 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.

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.

Comments: The transit service availability 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 availability index is a measure of how well service demanded is served.

It would be difficult to justify late-night welfare-to-work service using this measure with the default NPTS data, because 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—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 that had transit as an option (spatially and temporally) were made by transit, in comparison 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 claim that transit service is not well used, based on mode split data.

Needle, Jerome A., and Renée M. Cobb

"Improving Transit Security"
TCRP Synthesis of Transit Practice 21
Transit Cooperative Research Program, Transportation Research Board, Washington, D.C., 1997
http://nationalacademies.org/trb/publications/tcrp/tsyn21.pdf

Context: Synthesis of approaches and strategies for improving transit security

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology
- ☒ Other: Research report

Transit Systems Evaluated: Forty-five agencies in the questionnaire; Los Angeles, Houston, Phoenix, Philadelphia, Chicago, and Ann Arbor in the case studies

Transit Modes Considered: Urban fixed-route bus, light rail, heavy rail, commuter rail

Service Contracting Addressed? No

Performance Measures Identified:

- *Comfort & convenience:* Safety, security

Summary: The report begins with a discussion of the nature and extent of transit crime. It then describes 23 strategies that surveyed agencies reported to be effective in deterring transit crime. The authors classified these 23 strategies into five "strategy classes." The strategy classes are:

- Technological (cameras, closed circuit television, emergency telephones)
- Uniformed officer (concentrated patrols, truancy sweeps)
- Non-uniformed officer (undercover officers)
- Community outreach (interaction with schools and board of education, on-board cameras, "Crime Stoppers" programs)
- Other (training bus drivers to deal with law enforcement, gang awareness training, revocation of riding privileges)

The paper contains many examples of crime prevention programs in use today. The four transit crime case studies (Houston, Los Angeles, Ann Arbor, and Philadelphia) target decreasing ridership, increasing costs of vandalism, bus system disruption, and perceptions of disorder.

Comments: This synthesis discusses issues and solutions, not performance measures.

Ostria, Sergio, et al.

"Guidance for Communicating the Economic Impacts of Transportation Investments"
NCHRP Report 436
Transportation Research Board, Washington, DC, 1999

Context: This document is intended to provide transportation organizations, planning practitioners, and transportation decision makers with practical guidance for developing, considering, and explaining economic rationales for transportation investment decisions.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☒ Market research
- ☐ Performance reporting
- ☐ Applications of technology
- ☒ Other: Lessons learned

Transit Systems Evaluated: Regional multi-agency transportation planning efforts were evaluated, rather than the planning efforts of specific transit agencies. The selected demonstration sites were the metropolitan areas of Detroit, MI, Seattle, WA, and Tampa, FL.

Transit Modes Considered: Urban fixed-route bus, urban demand-response (general public and specialized), light rail, commuter rail, ferry

Service Contracting Addressed? No

Performance Measures Identified:

- *Community-based:* See the summary.
- *Economics/productivity:* See the summary.

Summary: Recent federal transportation policy, as embodied in the in the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and the Transportation Equity Act for the 21st Century (TEA-21), placed a high priority on consideration of economic performance in transportation planning and decision making. This shift represents a shift away from predetermined modal decisions toward broader consideration of tailored multimodal solutions within the context of transportation performance expectations and investment commitments. As such, this emphasis is intended to result in transportation plans, programs, and decisions that are driven by the needs of the specific area as opposed to the modal restrictions of the funding source or program. Given this emphasis, transportation planning and development is to be based on decisions that reflect the unique needs and characteristics of the area, including the expectations of economic contribution associated with transportation strategies and investments.

This guide explores the awareness and understanding of decision makers and the general public in regard to the linkages between transportation investments and economic performance on a national and regional basis. The guide is intended to assists state DOTs, MPOs, and other transportation agencies in proactively communicating economic rationales for transportation investments, by soliciting and assessing stakeholder inputs and by tailoring supporting information to their unique requirements. Part I of the guide is designed to provide strategies for more effectively communicating the economic implications of transportation decisions. Part II presents the cumulative findings and documented multi-layered approach employed by the research team in conducting community-based opinion and needs assessment, as a basis for developing specifically targeted strategies to communicate the positive economic and quality of life benefits of transportation investments.

Findings indicate that transportation stakeholders—primarily policy makers and business executives—have a greater awareness of the strong impact transportation investments have on economic performance than does toe h public at large. Public understanding varies along several parameters, including regional boundaries and socioeconomic factors, and can be further stratified by level of awareness of, and concern for economic issues.

Market research conducted under NCHRP Project 2-22 strongly suggests that messages on the economic benefits of transportation investments are not always sufficient to create public support for transportation investments, particularly when competing public priorities are involved. This research also suggests that transit and transportation planning agencies can benefit from additional insight in public and stakeholder response to alternative economic impact messages.

Comments: The Guide provides national benchmarks against which transit agencies can measure their own stakeholder and publics understanding, awareness, and preferences for alternative economic and quality of life messages in regard to transit investments. It also provides practical help in the form of generic survey instruments and strategies for developing messages, based on unique market research results. The Guide broadens the scope of the environment in which transit agencies operate to the larger market-based environment must operate, outside the parameters of traditional determined system performance measures.

Perk, Victoria A., and Dennis P. Hinebaugh

"Current Practices in the Use of Service Evaluation Standards at Public Transit Agencies"
Transportation Research Record 1618
Transportation Research Board, Washington, D.C., 1998

Context: Results of North American service standards survey as part of a review of existing service planning guidelines

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology
- ☒ Other: Development of service standards

Transit Systems Evaluated: Metro-Dade Transit Agency (MDTA) and 25 surveyed systems

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified:

- *Service delivery:* Number of standees, miles between road calls

Summary: The purpose of the telephone survey described in this paper was to learn about other transit agencies' experiences with service guidelines and standards. Specific topics of interest included:

- The types of standards or guidelines used and why they have been updated
- How the standards or guidelines are applied in service planning decision-making (e.g., how strictly they are applied and the problems associated with them)
- The structure of the agency's governing body and its relationship with planning staff

Financial constraints, politics, and provision of service to transit-dependent riders were found to limit adherence to service standards.

Comments: This paper is most relevant to TCRP G-6 in providing insight on developing, adopting, and adjusting service standards. These topics are addressed in terms of the strictness of the standards and in terms of working with agency governing bodies.

Peskin, R.L., S.R. Mundle, and S.D. Buhrer

"Privatization in Denver: Experience in the First Year"
Transportation Research Record 1349
National Academy Press, Washington D.C., 1992

Context: Journal article

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Three bus operators in Denver

Transit Modes Considered: Urban fixed-route bus, urban demand-response (specialized)

Service Contracting Addressed? Yes

Performance Measures Identified:

- *Community-based:* Complaints (operator performance complaints per 100,000 passengers)
- *Comfort & convenience:* Safety (bodily injuries per 100,000 passengers and property damage accidents per 100,000 vehicle miles); maintenance reliability (road calls)
- *Service delivery:* Service delivery compliance (revenue hours and vehicle miles); liquidated damages (number of observed lack of compliance by operators, for which liquidated damages can be assessed under the contract)
- *Speed & delay:* On-time performance (late, early, on time)

Summary: The paper reviews the experience of Denver in the first year of privatizing the bus operations, analyzing the actual cost and profitability, the safety and quality of service, and the contractors' compliance with the terms of their contracts. The final conclusion was that it is possible to reduce the net cost by contracting for transit services from private providers.

The bus services were divided into the following categories: local/limited radial routes (entering downtown Denver); local/limited non-radial routes (not entering downtown Denver); express; and circulator (mainly suburbs to nearby commercial areas), in addition to a service for persons with disabilities.

Comments: The weaknesses of the incentive penalty system used were:

- *Limited financial impact* – The dollar amount was too small to be of significance to the operator.
- *Limited opportunity for operator control* – Incentives for the contractors for good quality service were based on fare revenue; however, the operator did not have control of the fare revenue with the fare structure imposed.
- *Inconsistent observations* – The liquidated damages were imposed based on observations from a variety of sources with no consistency or uniformity guarantees.

Petersen, Eric

"Investigating Transit Access in Northeastern Illinois"
Paper 00-1215, presented at the Transportation Research Board 79th Annual Meeting
Transportation Research Board, Washington, D.C., January 2000

Context: Source and audience unknown, but related to the Chicago Area Transportation Study

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Chicago Transit Authority (CTA), Metra (commuter rail), and Pace (suburban bus and vanpool)

Transit Modes Considered: Urban fixed-route bus, heavy rail, commuter rail

Service Contracting Addressed? No

Performance Measures Identified:

- *Transit availability:* Service frequency, service density

Summary: In this paper, two transit accessibility measures are developed to compare transit service levels with demographic information in order to assess the equity of transit service in Northeastern Illinois as part of the Chicago Area Transportation Study (CATS). The two measures developed are:

- Service frequency, or the hourly average number of buses and trains passing through a zone within walking distance (0.5 mile for rail and 0.25 mile for bus)
- Service density, or the number of different routes passing through a zone (which roughly assumes that more routes equals more access)

The process by which these measures were developed and applied is as follows:

- Transit service was determined by zone.
  - Buffers were constructed around bus routes (with stops typically less than two blocks apart) and rail stations.
  - Buffers were intersected with a zone system (with each zone including approximately 0.25 square mile).
  - Buffer data, including zone number and area, were extracted for calculations.
  - The geographic area covered by the buffer was compared to the zone's total area. (This assumed a uniform population distribution across the zone.)
  - This was multiplied by the average hourly transit frequency, which is the sum of all buses and trains passing within walking distance divided by 138 hours. (This covers weekdays from 6 a.m. to midnight.)
  - All information was then summed by zone and compared to other sources for verification.
- Demographic data were incorporated into the zone system. (This required conversion of census traffic analysis zones into CATS study zones.)
- Transit levels were matched with demographic information and analyzed.
  - The distribution of transit frequency for all zones with a specified number of minority individuals was calculated and compared against regional values. (The number of minority individuals ranged from 100 or more to 5,000 or more.)

- A correlation analysis was performed to see how well transit frequency and service density matched unemployment levels.
- "High-risk" zones were identified. High-risk zones are zones in which at least half of the population is considered "disadvantaged" and transit service is very low.

The study concluded that transit access does appear to be inequitably distributed across Northeastern Illinois and some rural zones and the high-risk zones are worthy of further investigation.

Polus, Abishai, and Andrej B. Tomecki

"A Level-of-Service Framework for Evaluating Transportation System Management Alternatives"
Transportation Research Record 1081
National Academy Press, Washington, D.C., 1986

Context: Research project

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Springs, South Africa

Transit Modes Considered: All (generally)

Service Contracting Addressed? No

Performance Measures Identified: (Not specific to transit)

- *Service offered/utilization:* Person-hours of travel, person-miles of travel, number of vehicles by occupancy, vehicle-miles of travel, transit passenger miles of travel, number of transit passengers
- *Economics/productivity:* Energy consumption, emissions
- *Speed & delay:* Point-to-point travel time, vehicle hours of travel, vehicle delay

Summary: This paper demonstrates an indexing system for developing performance measures and provides examples of quality of service variables.

When evaluating improvements to a transportation system involving multiple modes and/or potential measures of effectiveness (MOEs), it is difficult to choose a single MOE that is applicable to all alternatives or to assign a cost to every variable. The proposed method assigns a locally chosen weighting to each desired MOE. The weighting is multiplied by the change in the MOE (compared to a base scenario), and the individual MOE scores are added together to obtain a "level of service of the transportation system" score for each alternative.

Pratt, Richard H. and Timothy J. Lomax

"Performance Measures for Multimodal Transportation Systems"
Transportation Research Record 1518
Transportation Research Board, Washington DC, 1996

Context: A presentation of concerns relating to multi-modal system performance measurement, and a description of travel time-based measures as ones that are readily understandable to measure mobility.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: All, in a multi-modal context

Service Contracting Addressed? No

Performance Measures Identified:

- *Comfort & convenience:* Accessibility
- *Speed & delay:* total trip time, average trip travel rate, travel time or difference in travel time, delay rate, total delay, relative delay rate, delay ratio, speed of person movement, corridor mobility index, and congested travel (in person-miles).

Summary: Traditional highway capacity oriented performance measures have limitations when used for multi-modal analysis, congestion management and growth management. Performance measures must be consistent with the goals and objectives of the process in which they are being used. A clear understanding of the role that performance measures are to play is required when designing and selecting them. Performance measures that focus on key aspects of trip making choices and plan evaluation can illustrate the effect of potential solutions. The authors focus on travel-time as a common thread in both trip making choices and in plan evaluation and suggest that travel-time based measures have a better chance of satisfying the full range of analytical needs.

The paper includes a discussion of the uses of transportation performance measures. A cross-classification of uses of congestion performance measures (purposes to which congestion measures are put against different classes of transportation studies) is presented. The users of transportation performance measures are also identified. Characteristics of effective performance measures are discussed highlighting the multiple demands placed on measures.

Definitions of congestion, mobility and accessibility are presented. The authors state that for transit systems, while congestion affects quality, it may be overshadowed by other transit characteristics such as frequency and route coverage, or lack thereof. For transit, more users could result in better service because more frequency and coverage become practical. Mobility and accessibility measures together can address the needs of cross-modal comparisons. Door to door travel-time is presented as the accessibility measure by which alternative modes can be put on an essentially equal footing, as long as it is recognized that acceptability varies by mode. Definitions of some data terms are presented followed by descriptions of basic mobility performance measures that are based on travel-time. Some of these measures may not be easily understandable.

Measures that can be applied to transit analysis are also identified (see previous page listing). These measures require that information is obtained or estimated about all parts of the transit trip. Similar level of analysis will be required of other modes if cross-modal comparisons are to be made.

A discussion is included of performance measurement techniques for locations (spots), corridors and regional transportation networks. For each level of analysis basic performance measures are identified and an example of how these measures may be applied to typical situations is provided.

Comments: This paper builds upon the ideas presented in NCHRP Project 7-13, "Quantifying Congestion".

Prioni, Paola, and David A. Hensher

"Measuring Service Quality in the Provision of Scheduled Bus Services"
Presented at the 6th International Conference on Competition and Ownership of Land Passenger Transport
Capetown, South Africa, September 1999

Context: Development of a revealed preference/stated preference (RP/SP) model of service quality choice and a service quality index to measure service effectiveness

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology
- ☒ Other: Model development

Transit Systems Evaluated: Twenty-five private operators in New South Wales, Australia

Transit Modes Considered: Urban fixed-route bus, rural (general public)

Service Contracting Addressed? Yes

Performance Measures Identified:

- *Transit availability:* "Network indicator"
- *Service offered/utilization:* Service quality index (a measure of service effectiveness reflecting reliability, fare, walking distance to the bus stop (in minutes), waiting safety, travel time, bus stop facilities, air conditioning, information at the bus stop, frequency, safety on board, cleanliness of seats, access to the bus, and driver attitude)
- *Economics/productivity:* Output (vehicle-kilometers, passenger trips, bus-miles)

Summary: The authors define quality of service as "a set of attributes that each user perceives to be the sources of utility or satisfaction in bus use" and state in the first sentence of the paper that measuring quality of service is an *empirical* problem. The authors divide quality of service into six classes of supply-side and demand-side "effects." These are listed in the table below.

Demand-side Effects	Supply-side Equivalence*
"Getting to the Bus Stop" Quality • Ease, safety, time (distance), knowing where the bus stop is	"Getting to the Bus Stop" Quality • Frequency, availability of bus shelter and seats
Wait Quality • Wait time at stop, punctuality of bus • Wait comfort, wait safety	Wait Quality • Frequency • Availability of bus shelter and seats
Trip Quality • Time to board a bus • Time to get a seat • Moving to your seat • Travel time • Trip cost	Trip Quality • Frequency, percent of low-floor buses • Number of seats available • Average speed, network shape • Travel time • Fare
Vehicle Quality • Cleanliness • Comfort of seats (types), spaciousness • Temperature control (ventilation) • Noise • Safety • Modernity • Ease of use for those with disabilities	Vehicle Quality • Hours of vehicle cleaning/vehicle • Percent of buses with cloth seats • Percent of buses with air conditioning • Visual surveillance • Average age of the fleet • Wheelchair access (yes/no)
Driver Quality • Appearance • Helpfulness	Driver Quality • Years of driving experience, money spent on drivers' training
Information Quality • Pre-trip information	Information Quality • Availability of timetable/destination signs

*The agency has some control over these.

The authors also derive a service quality index (SQI) to measure service effectiveness. The index is calculated based on the weights given to service attributes in the RP/SP model of service quality. The SQI is one component of a travel demand estimate, which takes the form:

$$y = d\ (y_s, SQI, c, m, r)$$

In this equation, y is the output service quality, d is rider demand, y_s is the input service quality, c is the cost of competing modes, m represents rider income, and r represents socioeconomic variables. By including service quality on both sides of this equation, the authors state that service quality is both an input and an output.

The authors take an empirical approach to estimating the parameter weights. Thirteen "key service attributes" were identified from a review of the literature and a survey of agency experiences. These attributes are: reliability, fare, walking distance to the bus stop (in minutes), waiting safety, travel time, bus stop facilities, air conditioning, information at the bus stop, frequency, safety on board, cleanliness of seats, access to the bus, and driver attitude. (Each of these is broken into three levels. Reliability, for example, is categorized by "on time," "five minutes late," and "10 minutes late.")
Bus users in New South Wales were surveyed to discover their preferences for different transit service packages, and a statistical model was developed. The authors found that the most significant service attributes were service reliability, fares, access time, and travel time. Information in the form of a timetable was also significant, but bus stop infrastructure did not appear to be "a major influence" on service quality. Nor was car availability significant. Accessibility was not found to be particularly

significant, but most of the surveyed bus users were not disabled or elderly. The authors found no differences in service quality preferences between rural and urban systems, but they are careful to say that this does not imply that the levels of service for rural and urban systems are the same.

Comments: The authors make a good point about the quality of transit service supplied being a response to consumer preferences. Quality of service is both an input and a product.

The authors write, “We restrict our analysis to actual bus users but recognize that non-users also provide useful information on the levels of service offered by bus operators.” The non-user’s view of transit performance is also worth considering (by other means), as non-users represent potential new riders.

The authors found that older individuals with higher incomes preferred existing transit service packages. They concluded, “What this suggests is that, as individuals age and increase their income, they see existing service quality as increasingly satisfying their requirements for service quality.” However, there was nothing in the survey to measure and control for an individual’s changing transit preferences over a long span of time. What the finding may suggest is that people with higher incomes are more likely to be choice riders who have simply chosen to ride because the existing service meets their needs. The authors did not state whether choice rider status is correlated with income or if age is correlated with income.

The model’s correlation coefficient, as presented in this paper, is not particularly good—only 0.32. However, Hensher and others have conducted additional work to improve the model, and presented an updated version of the model with better correlation at the 2002 TRB Annual Meeting.

Public Technology, Inc.

Proceedings of the First National Conference on Transit Performance
Prepared for the Urban Mass Transportation Administration
Washington, D.C., 1978

Context: This report summarizes the papers, lectures, and issues addressed at the First National Conference on Transit Performance in Washington, D.C., 1978.

Applicability to G-6 Project:

- [ ] Performance-measurement program description(s)
- [x] Characteristics of effective performance measures or measurement systems
- [ ] Performance measure examples
- [ ] Market research
- [ ] Performance reporting
- [ ] Applications of technology

Transit Systems Evaluated: No specific systems were evaluated.

Transit Modes Considered: None

Service Contracting Addressed? No

Performance Measures Identified: None

Summary: The major result of the conference, as reported in its proceedings, was a formal differentiation between effectiveness measures (how well a system meets its goals) and efficiency measures (how well a system utilizes its resources). Other findings were that transit system goals should be set locally first and then adapted to fit more general State and Federal goals for transit. Also reported was the need for UMTA (now the FTA) to take a lead role in data gathering, data sharing, and informational oversight to serve as a resource for local performance measurement programs. Specific attention was also given to the relationship between labor and management, urging both to be aware of the need to work together to provide effective transit solutions. Towards this end, the report suggested having up-to-date information and empowering a single representative with negotiating powers.

Comments: The major message of the speeches and papers found in these proceedings was that performance measurement is a viable and necessary tool to combat cost inflation and decreased ridership.

Pursula, Matti, and Minna Weurlander

"Modeling Level-of-Service Factors in Public Transportation Route Choice"
Transportation Research Record 1669
National Academy Press, Washington, D.C., January 1999

Context: Revealed preference/stated preference survey of Helsinki metro area transit users to identify the relative importance of "LOS factors"

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology
- ☒ Other: Model development

Transit Systems Evaluated: Helsinki, Finland

Transit Modes Considered: Urban fixed-route bus, commuter rail

Service Contracting Addressed? No

Performance Measures Identified:

- *Transit availability:* First service headway, total walking time, number of transfers, transfer walking distance
- *Comfort & convenience:* Transfer environment, fare
- *Service delivery:* Reliability, seat availability
- *Speed & delay:* Equivalent door-to-door travel time, total travel time, total transfer time

Summary: This paper discusses a survey undertaken in the Helsinki, Finland, metropolitan area to assess the relative importance of various quality of service variables, which the authors term "LOS factors." Relative importance is conveyed in terms of logit model coefficients and in terms of door-to-door travel time.

The findings of the paper are:

- Clear differences in LOS factor weights are associated with some demographic distinctions.
- Transfers, walking times, waiting times, and seat availability are the most important LOS factors.
- One transfer is equivalent to approximately 10 minutes of door-to-door travel time.
- Passengers prefer "organized" transfers, or transfers where the walking time and wait time are less than two and three minutes, respectively.
- Passengers are willing to travel 15 minutes longer if a seat is available. This is a higher disutility than that associated with a single transfer.
- The disutility associated with two transfers during one trip is higher than twice the disutility of a single transfer.
- Coverage and quality of service can be increased by providing high-quality transfer service.

Comments: The authors say that one transfer is equivalent to approximately 10 minutes of door-to-door travel time, and say that a previous study's finding of a 24-minute transfer penalty is "unrealistically high." Both numbers might be reasonable, depending on total trip length or other factors. The authors also say, "...for a non-user or random user of public transportation, a transfer is not so important an LOS factor as it is for everyday users." However, transfers may be more important to infrequent users in many cases, as they introduce an additional unfamiliar process into making a trip by transit. This points out that the perspective of regular riders can be different from that of infrequent riders.

Queensland Transport

Personal Communication with Mr. Chris Nash
Queensland Transport, Brisbane, Queensland, Australia

Context: List generated in response to the project team's inquiry on the performance indicators used by Queensland Transport (QT)

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: CityTrain and TravelTrain services (Queensland Rail)

Transit Modes Considered: Commuter rail

Service Contracting Addressed? Yes

Performance Measures Identified:

- *Community-based:* Customer satisfaction survey
- *Comfort & convenience:* Special services; safety and security (number of incidents involving passengers and number of incidents of vandalism and graffiti on train)
- *Service delivery:* Reliability - the scheduled and unscheduled services that were cancelled (by corridor); number of services scheduled
- *Service offered/utilization:* Number of journeys (by origins, destinations, day of week, line section, ticket, and passenger types); train kilometers (by line section); passenger loading factors (by corridor); boardings and alightings (by station peak times)
- *Economics/productivity:* Revenue (by line section, ticket, and passenger type)
- *Speed & delay:* On-time (percent of services within 3 minutes and 59 seconds of scheduled arrival; by corridor and time of day)

Summary: The performance measures used by Queensland Transport (QT) in the rail service agreements are listed above.

Radow, Lauren, and Chris Winters

Rural Transit Performance Measures
Rural Transportation Assistance Program (RTAP), Technical Assistance Brief # 19, Washington, DC, 1996

Context: Development of performance measures evaluating rural transportation's contribution to local, state, and national goals.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology
- ☒ Other: Development of societal benefit measures

Systems Evaluated: None

Transit Modes Considered: Rural (general public and specialized)

Service Contracting Addressed? No

Performance Measures Identified:

- *Community-based:* Economic impact, regional development, jobs directly and indirectly provided, individuals not on welfare, impact on air quality

Summary: Radow and Winters' approach first provides an overview of some of the performance measures that rural transit managers can use. It then proceeds to downplay the relative importance of those measures, indicating that many were actually developed for larger and urban systems and hence do not fully measure the impact of rural transit. It is then recommended that rural transit agencies develop alternate measures that assess community benefits.

The authors' goal is to strengthen the attractiveness of rural transit, recognizing that traditional measurements can be harmful to that perspective. Productivity, cost per passenger, and ridership, among other performance indicators, are traditionally significantly lower in a rural transit setting.

Radow and Winters advocate utilizing broad benefit measures. Many of the measures are extremely complex for a small rural operator to measure. Examples are benefits of air quality and impact on regional economic development. Other measures hold some promise, such as jobs provided or employees working or off welfare. Some that are classified as nontraditional performance measures are purely anecdotal passenger testimonials. While these positive testimonials may have a valuable public relations component, classifying them as a performance measure is dubious at best.

Comments: The authors' approach misses a significant range of performance measures that are significant and potentially valuable. Those measures are the ones that measure performance from a quality perspective. Given the nature of rural service, these are also measures where rural services often do not perform well as compared to large urban systems in certain areas. But to not measure customer quality as a result of these concerns overlooks the reality that the existence of rural transit service (versus no service at all) is important and service quality composes a lot of the attractiveness of the service.

Rural transit systems are comparable to ADA paratransit systems in many respects:

- Both generally have low levels of productivity versus urban fixed-route service.
- Both generally have higher costs per trips than urban fixed-route service.

- Both generally have high levels of coordination with social service agencies.
- A very large percentage of rural transit is demand-responsive. It may be ADA paratransit but it may also be non-ADA (senior or disability), Medicaid, or general paratransit.
- Many of the cost constraints are similar in rural transit and paratransit. Increased ridership, if unaccompanied by improved productivity, results in either increased cost and/or increased strains on service.

Reed, Thomas B., Richard R. Wallace, and Daniel A. Rodriguez

"Transit Passenger Perceptions Regarding Transit-related Crime Reduction Measures"
Paper 00-1349, presented at the Transportation Research Board 79th Annual Meeting
Transportation Research Board, Washington, D.C., January 2000

Context: Analysis of a survey of transit riders to assess passenger perceptions of transit crime reduction measures and identify which measures are most effective in making riders feel safer and more secure

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology
- ☒ Other: Survey and discussion of issues

Transit Systems Evaluated: Riders from 74 transit systems throughout Michigan (approximately half of all Michigan transit agencies)

Transit Modes Considered: Urban fixed-route bus, rural (general public)

- ☐ All
- ☐ None
- ☒ Urban fixed-route bus
- ☐ Urban demand-responsive transit (general public)
- ☐ Urban demand-responsive transit (specialized)
- ☒ Rural (general public)
- ☐ Rural (specialized)
- ☐ Light rail
- ☐ Heavy rail
- ☐ Commuter rail
- ☐ Ferry
- ☐ Other: ______________________________

Service Contracting Addressed? No

Performance Measures Identified:

- *Comfort & convenience:* Safety, security
- *Service delivery:* Reliability

Summary: The authors of this paper classify transit crime reduction measures into the following categories:

- Patrol and security
- Design actions
- Technological innovation
- Transit service improvements
- Media and information campaigns
- Increasing sanctions of offenders

The findings and conclusions of this study are:

- The surveyed passengers generally feel safe on public transit.
- Passengers feel less safe on transit at night than during the day.
- Passengers on small transit systems feel safer than passengers on larger transit systems.

- Women generally rate the level of perceived safety lower than men do.
- Captive riders generally rate perceived the level of perceived safety slightly lower than choice riders do.
- People who have experienced a crime on a transit system generally rate their level of personal safety lower than those who have neither seen nor been the victim of a crime on a transit system.
- Passengers who rate their personal safety lower tend to value safety enhancements more.
- Installation of emergency phones and increased lighting at stops were the improvements generally rated highest by surveyed riders.
- Most passengers dislike limited weekend and nighttime service.

Comments: This paper is a discussion of issues and solutions, not a discussion of performance measures. The authors connect service reliability with crime deterrence, however, as more reliable service means passengers spend less time waiting at transit stops.

Regional Transportation Authority – Chicago

Peer Review: FY 1998 Data
Regional Transportation Authority, Chicago, IL, January 2000

Context: Annual comparison of Chicago systems to peer systems

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Metra, Chicago Transit Authority (CTA), and Pace Suburban Bus Service

Transit Modes Considered: Urban fixed-route bus, suburban commuter bus, heavy rail, commuter rail

Service Contracting Addressed? No

Performance Measures Identified:

- *Maintenance:* Spare ratio, average active fleet age
- *Transit availability:* Directional route miles, train miles per directional route mile, stations per directional route mile (effects operating costs and speed and delay)
- *Service delivery:* Occupancy rate, average trip length
- *Service offered/utilization:* Unlinked trips per total vehicle hour, passenger miles per total vehicle mile, miles per available vehicle, peak-to-base ratio
- *Economics/productivity:* Operating expense per total vehicle hour, operating expense per total vehicle mile, operating expense per unlinked trip, operating expense per passenger mile
- *Vehicular capacity:* Cars per train, average number of seats
- *Speed & delay:* Average speed

Summary: This report summarizes Chicago Regional Transportation Authority (RTA) comparisons of Chicago-area transit systems to "peer" systems through the country. The peers to which the Chicago-area systems were compared are listed in the table on the next page. The data come from the National Transit Database. Industry trends from 1990 to 1998 are analyzed.

Peer Groups by Mode	City, State
Commuter Rail System:	
Metra	Chicago, IL
Metro-North	New York, NY
Long Island Rail Road	New York, NY
Southeastern Pennsylvania Transportation Authority (SEPTA)	Philadelphia, PA
New Jersey Transit Corporation (NJT)	Newark, NJ
Urban Bus System:	
CTA	Chicago, IL
Washington Metropolitan Area Transit Authority (WMATA)	Washington, DC
SEPTA	Philadelphia, PA
New York City Transit Authority (NYCTA)	New York, NY
Massachusetts Bay Transportation Authority (MBTA)	Boston, MA
Suburban Bus System:	
Pace	Chicago, IL
Long Island Bus (MTA)	New York, NY
Orange County Transportation Authority (OCTA)	Los Angeles, CA
San Mateo County Transit District (samTrans)	San Francisco, CA
Alameda-Contra Costa Transit District (AC Transit)	Oakland, CA
Heavy Rail System:	
CTA	Chicago, IL
WMATA	Washington, DC
SEPTA	Philadelphia, PA
NYCTA	New York, NY
MBTA	Boston, MA

The performance measures identified are summarized below. The measures fall within the three categories of cost efficiency, cost effectiveness, and service effectiveness. This structure is based on a model developed by Fielding, Glauthier, and Lave in 1978.

Cost Efficiency Measures	Cost Effectiveness Measures	Service Effectiveness Measures
Operating expense per total vehicle hour	Operating expense per unlinked trip	Unlinked trips per total vehicle hour
Operating expense per total vehicle mile	Operating expense per passenger mile	Passenger miles per total vehicle mile

This paper also defines and reports spare ratio, miles per available vehicle, peak-to-base ratio, average speed, cars per train, directional route miles, train miles per directional route mile, average number of seats, occupancy rate, average active fleet age, average trip length, and stations per directional route mile. These measures are classified as “characteristics” of the service provided and are used to provide commentary on the systems’ comparative performance with respect to the measures in the table above.

Regional Transportation District – Denver

"2001 Performance Report – First Quarter"
Regional Transportation District, Denver, CO, June 2001

Context: Summary of performance goals and actual performance

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Denver (RTD, Laidlaw, and ATC)

Transit Modes Considered: Urban fixed-route bus, urban demand-response (specialized), light rail

- ☐ All
- ☐ None
- ☒ Urban fixed-route bus
- ☐ Urban demand-responsive transit (general public)
- ☒ Urban demand-responsive transit (specialized)
- ☐ Rural (general public)
- ☐ Rural (specialized)
- ☒ Light rail
- ☐ Heavy rail
- ☐ Commuter rail
- ☐ Ferry
- ☐ Other: ____________________

Service Contracting Addressed? Yes

Performance Measures Identified: See the table in the summary.

Summary: The following table summarizes RTD's performance goals and the measures used to evaluate achievement of the goals. The numbers can be found in the report.

Goal	Measures Used	2001 Target*
1. Provide safe transportation service	Vehicle accident ratio per 100,000 miles (system-wide)	<0.40
	Passenger accident ratio per 100,000 miles (system-wide)	<0.37
	Operator/passenger assault ratio per 100,000 boardings	<0.15
	Average response time to emergency dispatch calls	<30 seconds
	On-board security-related incidents per 100,000 miles	4.2
	Security-related incidents at park-and-rides with surveillance cameras	50
	Vandalism on buses using surveillance cameras	2,000
	Reportable light rail/auto accidents per month	<2.0
2. Provide clean transportation service	Average response time to public complaints	<24 hours
	Graffiti complaints per month	<5.0
	Facilities maintenance complaints per month	<12.0
	Dirty bus complaints per month	<1.5
	Overdue bus interior cleaning per month	<15.0
3. Provide reliable transportation service	Local on-time service (system-wide)	88.0%
	Regional and express on-time service	94.0%
	Light rail on-time service	99.0%

Goal	Measures Used	2001 Target*
	Missed pull-outs (RTD only)	<0.2%
	Mileage between lost service maintenance road calls (District)	>12,000
	Mileage between lost service maintenance road calls (RTD)	>13,500
	Mileage between lost service maintenance road calls (Laidlaw)	>8,500
	Mileage between lost service maintenance road calls (ATC)	>8,500
4. Provide courteous transportation service	Average Telephone Information Center (TIC) call wait time	<120 seconds
	Response time on TIC customer inquiries	<1 day
	Average response time to customer complaints	8 days
	Operator complaints per boarding	Not adopted
	Percent of passengers without complaints	Not adopted
	Schedule availability complaints per month	<1.00
	Average monthly visits to RTD web site	Not adopted
	Variable bus information signs installed at RTD facilities	10
5. Provide accessible transportation support service	Access-a-Ride on-time service	92.0%
6. Provide cost-effective and efficient transportation service	Operating cost recovery ratio	20.0%
	SB 154 cost recovery ratio	30.0%
	Overall ridership increase	4.6%
	Increase farebox revenue	5.0%
	Increase EcoPass revenue	5.0%
	Audits (of selected internal functions)	30
	Maintain bus operator headcount within authorization	<7.5%
	Maintain bus mechanic headcount within authorization	<7.5%
	Stock-out level	<1.2%
7. Meet the future transportation needs of the District	Timely completion of the Southeast Corridor (by task)	
	Timely completion of the Central Platte Valley Corridor	
	Park-and-ride opening dates (by project)	
	Timely completion of bus and rail maintenance facilities (by task)	
	Property management (by task)	
	Deliver civic and neighborhood presentations to communicate with the public regarding service issues (by department)	Not adopted
	Perform transit-oriented development station profiles	6
	Make presentations on transit-oriented development to elected officials, private developers, or the general public	12

*May apply to Laidlaw and ATC as well as to RTD

Comments: RTD separates complaints by type instead of relying on a broad, undifferentiated complaint rate measure. The cleanliness measures above, for example, include complaints related to vehicle and facility cleanliness. RTD also has targets for each type of complaint. This does not seem to be a common practice. Theoretically, such categorization and target setting would provide more insight into riders' perceptions and the effectiveness of the agency's improvement efforts. It would be interesting to learn if this is the case.

Including stakeholder presentations and adherence to capital project construction timelines in the performance measurement program is uncommon.

Regional Transportation District – Denver

"Performance Evaluation with a Family of Services"
Regional Transportation District, Denver, CO, April 2000

Context: Denver Regional Transportation District (RTD) implementation of common performance measures for a range of markets and services

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Denver RTD

Transit Modes Considered: Urban fixed-route bus, urban demand-response (specialized), light rail

Service Contracting Addressed? No

Performance Measures Identified:

- *Economics/productivity:* Subsidy per passenger, passengers per mile, passengers per trip, passengers per hour

Summary: To investigate performance evaluation with a family of services, Denver Regional Transportation District (RTD) classified its services as:

- Local
  - Suburban (low density, no CBD)
  - Urban (higher density, no CBD)
  - CBD (high density, to downtown Denver)
- Metropolitan
  - Regional
  - Express
  - SkyRide
- Special Services (including event services)
- Access-a-Ride (ADA demand-responsive)
- Other services
  - Longmont School Trippers
  - 86X
  - Light rail transit
  - Mall shuttle
  - New routes 160, 210, B-line, 145X, and 185X
  - Discontinued routes

The productivity and effectiveness of these services were then evaluated. RTD defined productivity in terms of passengers per hour and effectiveness in terms of subsidy per passenger. Passengers were represented by unlinked boardings, hours are revenue hours, and subsidies are costs less fare revenues. Passengers per hour was plotted against subsidy per passenger to allow comparison of the services on a single graph.

According to the document, the advantages of this procedure are:

- It is a simple, easily understood method for allocating financial resources.
- It is tied to the effectiveness objective.
- New and alternative services can be compared.
- Multiple standards do not need to be set at the policy or overall level.

Regional Transportation District – Denver

Service Standards
Regional Transportation District, Denver, CO, January 2000

Context: Update of service standards adopted in 1999

Applicability to G-6 Project:
- ☒ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Denver RTD

Transit Modes Considered: Urban fixed-route bus, urban demand-response (specialized), light rail

Service Contracting Addressed? Yes, briefly

Performance Measures Identified:
- *Transit availability:* Coverage area, route spacing
- *Service delivery:* Load factor
- *Service offered/utilization:* Passengers per mile, passengers per hour
- *Economics/productivity:* Subsidy per passenger, farebox recovery ratio
- *Speed & delay:* Travel time to CBD

Summary: The purpose of the Denver Regional Transportation District (RTD) standards is to provide consistency in evaluating service change proposals and "ensure that the service being provided represents the most cost-effective use of the District's resources." These standards are reviewed biannually, but ridership, revenue, and costs are updated annually. Targets in the January 2000 update are based on 1998 ridership and costs.

Fixed routes are evaluated by ridership (boardings per service mile or per trip) and by subsidy per passenger. The standards for each measure are based on the least productive 10 percent of the routes (by ridership or by subsidy) or on the least productive 25 percent of the routes (by ridership and subsidy combined). The following table summarizes these measures and standards by class of service. Routes can be evaluated as a whole or in segments (e.g., by branch), or specific trips can be evaluated.

Fixed-route Productivity Measures and Standards by Class of Service*

Class of Service	Ridership			Economic		
	Measure	Minimum Standard		Measure	Maximum Standard	
		10%	25%		10%	25%
Local CBD	Passengers/mile	1.46	1.73	Subsidy/passenger	$5.18	$3.94
Local Urban	Passengers/mile	0.84	1.13	Subsidy/passenger	$9.34	$4.96
Local Suburban	Passengers/mile	0.35	0.53	Subsidy/passenger	$13.90	$10.96
Express	Passengers/mile	15.64	18.76	Subsidy/passenger	$9.49	$6.95
Regional	Passengers/mile	11.43	15.46	Subsidy/passenger	$12.21	$9.34
skyRide	Passengers/mile	16.98	23.34	Subsidy/passenger	$4.10	$3.39

*For route segments and specific trips, these standards may change.

The following table summarizes ridership and subsidy standards for non-fixed routes outside of special services such as RTD's ADA service. These standards are new and are in development.

Non-fixed-route Productivity Measures and Standards by Class of Service

Class of Service	Ridership			Economic		
	Measure	Minimum Standard		Measure	Maximum Standard	
		10%	25%		10%	25%
On demand	Passengers/hour	Initial (3)		Subsidy/passenger	TBD	TBD
Subscription	Passengers/mile	75% seat load factor		Subsidy/passenger	TBD	TBD

Area coverage standards are summarized in the table below.

Area Coverage Standards outside the Denver CBD

Density	Standard(s)
3-12 residents and employees per acre	Minimum: peak period park-and-ride service if travel time to the CBD by express bus or by a bus/rail timed connection exceeds 20 minutes
	Maximum: local service along major arterials with pedestrian access within 1/4 mile
	Maximum: peak period, limited, express, or regional service from park-and-rides if travel time to the CBD by express bus or by a bus/rail timed connection exceeds 20 minutes
12+ residents and employees per acre	Minimum: local service on major arterials with pedestrian access within 1/4 mile
	Minimum: peak period, limited, express, or regional service from park-and-rides if travel time to the CBD by express bus exceeds 20 minutes
	Maximum: local service with 1/2-mile route spacing
	Maximum: limited, express, or regional service if travel time to the CBD by express bus exceeds 20 minutes

The minimum system-wide farebox recovery ratio is 30 percent. Farebox recovery ratio is calculated as:

$$\text{Farebox Recovery Ratio} = \frac{\text{Farebox Revenues + Advertising Revenues + Lease Revenues + FTA Operating Assistance + Other Non-Sales Tax Revenues}}{\text{Category I Costs + Category II Costs + Local Share of Depreciation on RTD Assets}}$$

The Standard for Service for Transit-dependent Persons and to Social Service Destinations "does not guarantee a minimum level of service to all transit-dependent riders. However, it will ensure that transit-dependent riders and/or the need to have access to social service destinations are identified and considered when decisions are made to reduce service levels in an area." Productivity standards in such a case are reduced by one-half of the transit-dependent ridership.

The minimum productivity standards for special services are 26 boardings per trip for SeniorRide and 30 boardings per trip for Senior Shopper. These standards are based on one-half of the average boardings per trip for the previous year.

Comments: This document contains standards for the design of new service. These include standards for directness of route, stop spacing, minimum service frequency, maximum load, and roadway geometric design (e.g., lane width, overhead clearance, and presence of speed bumps). The document also contains standards for special event service and briefly describes standards for contracted services. The appendices to the document include a glossary, service class definitions, and 1998 rankings of routes and services by ridership and subsidy per passenger.

Note that the "farebox recovery ratio" used by RTD includes all revenue other than local sales taxes, and not just fare income. Most other agencies call this an "operating ratio" or "cost recovery ratio."

Reilly, Jack M., and Thomas G. Guggisberg

"Use of Geographic Information Systems for Transit Service Performance Measurement"
Presented at the 76th Annual Meeting of the Transportation Research Board
Transportation Research Board, Washington, D.C., January 1997

Context: Agency investigation of GIS applications for transit service evaluation

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☒ Applications of technology

Transit Systems Evaluated: Capital District Transportation Authority (Albany, NY)

Transit Modes Considered: Applicable to any fixed-route service

Service Contracting Addressed? ☐ Yes ☒ No

Performance Measures Identified:

- *Community-based:* Number of households within 0.25 mile of a bus stop, accessibility (in terms of households without autos or other demographic data)
- *Transit availability:* Service provided between high auto-dependency zones and the closest downtown at least once each hour as warranted by ridership
- *Service offered/utilization:* Average weekday passengers by route, passengers per hour by route
- *Economics/productivity:* Revenue to cost ratio by route, margin (profit or deficit) per passenger by route, transit trips per square mile, transit users per square mile, annual cost per person or household in the service area, average cost per household without an auto in the service area

Summary: This paper is a demonstration of potential uses of GIS to determine various economic performance and accessibility measures for a transit system. The objectives of CDTA's investigation of GIS were:

- To show the use of GIS in operational analysis, such as by displaying usage information on route maps
- To show the use of GIS in developing performance measures reflecting mobility in the service area
- To apply GIS to journey-to-work data

The authors describe how CDTA's GIS is compatible with CDTA's other data gathering systems, how the GIS databases for bus stops, routes, and demographic/demand data were structured and developed, and the GIS techniques of geocoding, buffer analysis, thematic maps, and path alignment displays. Several CDTA projects to which GIS was applied are also described.

Comments: This paper provides insights on structuring transit service to achieve social and performance goals. For example, the authors show how GIS and Census data can be used to assess service provided to households without autos in terms of the destinations that those households can reach via transit. This is done by creating fields in the GIS database that identify routes that serve malls, etc. The paper also discusses techniques for presenting service evaluation data.

Rood, Timothy

"Local Index of Transit Availability: Riverside County, California, Case Study Report"
San Francisco, CA, January 1997

Context: This paper was written for the Local Government Commission to describe the Local Index of Transit Availability (LITA) and to present the results of applying the LITA to Riverside County, CA.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Riverside Transit Agency (RTA) in Riverside County, CA; Miami-Dade County, FL (in less detail)

Transit Modes Considered: Urban fixed-route bus, rural (general public), commuter rail

Service Contracting Addressed? No

Performance Measures Identified:

- *Transit availability:* Local Index of Transit Availability with capacity, frequency, and route coverage components; Regional Index of Transit Accessibility (RITA)

Summary: The LITA is a method of rating "transit service intensity," or transit availability, that is intended for use by service planners, land use planners, and policymakers. The purpose of the LITA is "to develop methods of accounting for transit service that could inform land use and transportation decisions, which are often made under assumptions of near-universal automobile travel without regard to accessibility by alternative modes." LITA applies to small analysis zones within a metropolitan region—ideally bus stop "catchment" areas but possibly census blocks, census tracts, or transportation analysis zones (TAZs). RITA, a more regional application of LITA, is "more data-intensive" and is not the focus of this paper.

LITA includes three components, which are standardized and combined to produce the overall LITA score. These components are:

- *Capacity* - Measured as seat-miles divided by total residential and employment population (recommended) or as seat-miles divided by peak load factor
- *Frequency* - Measured as the average number of transit vehicles per 24-hour day (including weekends)
- *Route Coverage* - Measured as route-miles per square mile or as transit stops per square mile (recommended)

The author recommends, for the capacity component, the seat-miles divided by total population measure because it is more consistent with the population/transit service relationship that the LITA is trying to capture. He recommends, for route coverage, the transit stops per square mile measure because it is "a more precise measure of access to transit" and recognizes that "transit is only accessible at its designated access points." Details on how seat-miles are calculated, how route-miles are measured, how bus stops are counted, and so forth are in the paper.

For each component, the standardized score is calculated using the average score and the standard deviation across all analysis zones under study. The author recommends that, for a "robust analysis," there should be at least 50 analysis zones and preferably more than 100. The overall LITA score is the unweighted average of the standardized component scores. Level of service (LOS) thresholds can be assigned to the overall LITA score based on an incremental number of standard deviations away from the mean. LOS "F" is equivalent to no transit service.

Including regional transit in the LITA score for Riverside County made no significant difference in the results, but the author recommends that the LITA be calculated both with and without regional transit. Leaving regional transit service out of the LITA score is a means of examining the availability of local feeder service.

The paper includes "policy responses" to combinations of the LITA, land use intensity, and walkability measures. The author writes that these three measures are necessary for successful transit-oriented development.

The appendix to the paper contains detailed instructions on how to use the spreadsheet developed by the author, which is available from the Local Government Commission and includes a sample metropolitan area.

Comments: The LOS thresholds are relative only to a specific study and cannot be used to compare different metropolitan areas.

Rosenheimer, David M., and John Dexter

"Measuring Results and Demonstrating Performance at Newark Airport Monorail"
Transportation Research Record 1669
National Academy Press, Washington, D.C., January 1999

Context: Design of a computer program to analyze transit vehicle operations logs and assist managers and technicians in identifying and prioritizing maintenance needs during system start-up

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☒ Applications of technology

Transit Systems Evaluated: Newark Airport (EWR), New Jersey

Transit Modes Considered: Automated guideway transit

Service Contracting Addressed? No

Performance Measures Identified:

- *Transit availability:* Ratio of number of stops to number of service hours, waiting time

Summary: Analysis metrics were developed to extract schedule adherence and alarm data from automated train control system logs to identify, diagnose, and prioritize maintenance needs. One question these metrics were used to answer was, "How well was service delivered today?" The Newark Airport monorail is a headway-based service, so the measures of service quality that are used focus on minimizing bunching and waiting time.

The authors conclude that the analysis metrics made it possible to quantify incidents based on operating time. Such incidents were previously described only with "unqualified opinion." The authors see the "establishment of the validity of patron claims about late service" as a future application of the project.

Rubenstein, Gary, and Kenneth Dallmeyer

"An Examination of Recent Transit Performance Measures for CTA, Metra, and Pace"
Presented at the 1993 Metropolitan Conference on Public Transportation Research
University of Illinois at Chicago, June 11, 1993

Context: This paper was written to compare three metropolitan Chicago transit authorities with peer agencies around the U.S. The paper also discusses specific performance measures with regards to their relative importance in evaluating a transit system's performance.

Applicability to G-6 Project:
- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Chicago Transit Authority (CTA), Pace, and Chicago Metra

Transit Modes Considered: Urban fixed-route bus, suburban commuter bus, heavy rail, commuter rail

Service Contracting Addressed? No

Performance Measures Identified:
- *Service offered/utilization:* Passengers per vehicle hour, passengers per vehicle mile
- *Economics/productivity:* Farebox recovery ratio, cost per vehicle hour, cost per vehicle mile, cost per passenger trip, cost per passenger mile

Summary: After conducting a peer group analysis for each of the three transit operators, the authors of this paper indicate that CTA consistently performs the best as compared to its peer agencies. Metra and Pace, on the other hand, perform strong in some areas and weaker in others. The authors point out that the performance measure comparisons can be misleading due to the different service characteristics of the various transit agencies. The paper also acknowledges that the peer group analysis did not consider the quality of transit service provided by each operator. All in all, while not the most robust performance measure report, this paper does provide a good example of a peer group analysis for a select group of transit operators.

Comments: All financial and operating data used in this paper are from 1991.

Ryus, Paul, et al.

"Development of Florida's Transit Level of Service Indicator"
Transportation Research Record 1731
Transportation Research Board, Washington, D.C., 2000

Context: Describes the development of Florida DOT's transit availability measure

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☒ Applications of technology

Transit Systems Evaluated: Test case in Tallahassee, Florida

Transit Modes Considered: Applicable to any fixed-route service

Service Contracting Addressed? No

Performance Measures Identified:

- *Transit availability:* Percent person-minutes served

Summary: This paper defines transit availability as "the degree of opportunity at a location to use transit service." Florida DOT's Transit Level of Service (TLOS) Indicator was developed from the idea that, at any given time, a transit vehicle is available to serve only the people who are able to walk to a transit stop and catch the vehicle without an excessive wait time. That is, if someone is located too far away to make it to the stop in time to catch a transit vehicle, transit is not available to that person until the next vehicle arrives. Likewise, if someone would have to wait at the transit stop longer than a specified maximum wait time, transit is not available to that person at that point in time. Thus transit is only "available" when:

- Stops are located near one's home, job site, and other destinations
- Safe and direct pedestrian linkages between transit stops and origins exist
- Transit service is reasonably frequent
- Transit service operates at the desired times of travel

The measure of transit availability, percent person-minutes served (referred to as the "TLOS Indicator"), is defined as "the average percent of time that people have transit service available (over time) and accessible (spatially) to them." The measure can be calculated using the TLOS software developed by the project described in the paper.

The TLOS software is designed to work with GIS data. Required data include: transit stop locations, transit routes, streets and pathways, and population and employment locations. Transit schedule data must also be provided by stop. The user defines maximum walk distances served by transit and maximum wait times. The software develops one-minute walk distance "buffers" around stops (either as air distances or by following walking paths along the street network) to determine which areas are served and at which times. The time required to prepare data for use with software is extensive.

The software was tested in Tallahassee, Florida, and found to produce results that were compatible with, but more detailed than, the availability measures in the *Transit Capacity and Quality of Service Manual*. It was also found to be useful in calculating adjusted mode splits, and it represented expected differences in availability across the day, the week, and the location within the city.

Comments: The TLOS software is designed to work with fixed-route transit. The principle also applies to demand-responsive service (number of people served multiplied by the amount of time service is offered) but is not explicitly calculated by the software.

The performance measure, percent person-minutes served, is not intuitive to someone with no basis for comparison. However, the measure can be directly measured in the field, unlike index measures. The measure combines aspects of transit availability and accessibility.

The performance measure assumes that everyone within a transit vehicle's service area actually wants to catch that particular vehicle, even if the vehicle is not going where the potential rider would like to go or if excess transferring would be required. More recent versions of the software have introduced a travel time measurement component for trips between two locations, and an adjustment factor reflecting pedestrian delays crossing busy streets.

St. Jacques, Kevin and Herbert S. Levinson

"Operational Analysis of Bus Lanes on Arterials"
TCRP Report 26
Transportation Research Board, Washington D.C., 1997
http://nationalacademies.org/trb/publications/tcrp/tcrp_rpt_26-a.pdf

Context: Research on bus capacity and speeds along arterial streets, particularly those with an exclusive bus lane. Project results were incorporated into the Transit Capacity and Quality of Service Manual and the Highway Capacity Manual 2000.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Exclusive bus lane operations in Houston, San Francisco, Los Angeles, and Chicago were used for field-testing new procedures.

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? No

Performance Measures Identified:

- *Service delivery:* Bus stop capacity, bus stop capacity-based level of service
- *Speed & delay:* Bus travel speed, speed-related levels of service

Summary: The research analyzes the operation of buses on arterial street bus lanes (in downtown streets) focusing on operating conditions where buses have full or partial use of adjacent lanes. The research demonstrates how increasing bus volumes can reduce speeds and how right turns from or across bus lanes can affect bus flow and relates to bus lane operations in the United States and Canada. The results show how the number of buses per hour, bus stops per mile, bus stop dwell times and service patterns, signal constraints, and traffic volumes in adjacent lanes affect bus lane speeds and capacities. Three separate types of bus lanes were analyzed. Specific research topics include bus stop capacity and bus travel speeds and service levels.

Within bus stop capacities, the berth capacity of bus stops obtained through simulations were compared to that obtained from applying the HCM formulas and tables. As a result of this, revised formulas for the capacity of a bus berth is provided. Some changes are also proposed to the levels of service thresholds for bus stops keyed to the approximate likelihood of queues forming behind the bus stop. Adjustment factors were developed to reflect the capacity gains resulting from skip-stop service and the capacity losses resulting from right-turn traffic conflicts.

Bus travel speed estimation procedures and equations are provided - one for a general approach, and another for a more detailed auxiliary approach when detailed information on traffic signal timing and coordination patterns is available. Speed related level of service thresholds for buses on arterials are also provided as a supplement to existing passengers per bus (load factor type) and buses per hour (frequency of bus service) descriptors of levels of service.

The authors make recommendations on potential modifications to the Highway Capacity Manual (HCM) based on the results of this research. These modifications relate to new capacity procedures for skip-stop operations and for right-turn impacts on bus lanes. Passenger capacity of a bus berth could also be modified to reflect the new procedures, parameters and service levels. Suggested additions to the HCM include the new speed-related level of service criteria and the methods for estimating bus lane speeds.

The research paper concludes by providing several bus service planning guidelines to improve the speed, reliability and capacity of bus operations.

Comments: The report's guidelines for estimating bus lane capacities and speeds along arterial streets (when buses have partial or exclusive use of adjacent lanes) fill an important void in the understanding of bus lane operations. The level-of-service thresholds for buses based on speed and the procedures for estimating speed of buses using bus-lanes can be useful in comparisons to the automobile mode. This makes possible the assessment of a "person LOS".

A follow-up project, published as *TCRP Research Results Digest 38*, conducted additional field tests of the speed calculation procedures, which resulted in some modifications to the calculation procedures, but also verified that the overall process was sound. The original speed-based level-of-service recommendations were kept intact.

San Francisco Municipal Railway (MUNI)

"A Plan to Fix MUNI: Appendix C. Report of the Service Performance Committee"
http://www.ci.sf.ca.us/muni/ptfmc.htm (no longer available on the Internet)
Dated March 4, 1999, and accessed September 16, 1999

Context: Findings of a task force formed to develop solutions to the agency's operational problems; Appendix C is the report of a committee that focused on service reliability improvements

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: San Francisco Municipal Railway (MUNI)

Transit Modes Considered: Urban fixed-route bus, urban demand-response (specialized), light rail, electric trolleybus, cable car

Service Contracting Addressed? Yes, limited discussion

Performance Measures Identified:

- *Transit availability:* Accessibility (ADA)
- *Service delivery:* On-time service, mean distance between failures, vehicle age, incidents per million miles
- *Service offered/utilization:* Scheduled revenue vehicle service hours

Summary: Section 5, "The Plan to Fix MUNI," describes the elements within the restructured MUNI organization. These elements address five issues, which are:

- Governance and duties
- Service standards, goals, and accountability (covers adoption of "measurable performance standards" and how to achieve those standards)
- Personnel system
- Funding
- Budget

The "service standards" section references 10 priority goals for MUNI service improvements. These are:

- Improve Customer Satisfaction and Communications (call for an annual survey of "key measures of customer satisfaction" and describes how MUNI will provide information to the public)
- Enhance System Safety and Security (based on incidents per million miles)
- Restore Published Scheduled Service (based on on-time service; a transit vehicle is "on time" if it arrives no more than one minute before and no later than four minutes after its scheduled time)
- 100% Operator and Maintenance Worker Availability
- Improve Maintenance and Availability of Rolling Stock
- Maintain Accessibility (ADA-focused)
- Establish Cost Control and Fare Policy
- Timely Rolling Stock Acquisition
- Modernize Information Management
- Complete Major Infrastructure Projects

The Service Performance Committee concluded that the then-current MUNI organizational structure was inadequate to meet these goals.

Savas, E.S., and A. Cantarella

A Comparative Study of Public and Private Bus Operations in New York City
City University of New York, Institute for Transportation Systems, New York City, NY, July 1992

Context: Research report

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: New York City bus operators

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? Yes

Performance Measures Identified:

- *Comfort & convenience:* Service quality and safety
- *Economics/productivity:* Cost-effectiveness and cost efficiency

Summary: The paper details the results of a comparison of the performance of public and private bus service in New York City. The private operators were found to be more cost-effective and cost-efficient, while the results for service effectiveness were mixed.

Schiemann, William A., and John H. Lingle

Bullseye! Hitting Your Strategic Targets through High-impact Measurement
The Free Press, New York City, NY, 1999

Context: Book about using performance measurement as a management tool; not written specifically for transit

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: None

Service Contracting Addressed? No

Performance Measures Identified: None

Summary: This book is intended for senior managers of a wide range of businesses, but it contains many interesting and relevant insights into the use of performance measurement as a management tool. These insights are summarized here. The book also contains survey data to support its contention that management by measurement is an effective business practice, plus several illustrative examples of how to put the book's guidelines into practice.

The authors begin by discussing the "measurement paradox." This is stated as "...the paradox in which there are so many companies with ineffective measurement systems in an environment that widely extols measurement but contains only a relatively small number of high performers."

"Key performance measurement perspectives" are identified. These illustrate the applicability of the book to transit performance measurement and include:

- *Market* – Includes customers and potential customers as well as competitors
- *Financial*
- *People* – Includes employees and subcontractors
- *Operations*
- *Environment* – Includes regulatory agencies, environmentalists, and the communities in which the organization operates
- *Partners/suppliers* – Includes suppliers of labor and materials and alliance or joint venture partners

The authors noted the following characteristics of measurement-managed organizations:

- A balanced set of performance measures is regularly monitored.
- Measures balance short- and long-term goals.
- Data are shared openly across the organization. Employees have access to information needed to make balanced decisions.
- Review meetings are primarily strategic.
- Organizational performance is seen as integrated.
- Measurement is used to define and communicate concepts.
- Understanding and commitment to the measurement strategy are high.

- All levels of performance measures (e.g., department and individual) are linked.
- Accountability and commitment are strong.
- Clear linkages exist between rewards and achievement of goals.

Criteria for evaluating a measure's "goodness" are:

- *Validity* – Does the measure capture what it is intended to?
- *Reliability* – Does the measure exhibit a minimum amount of error? Does the measure change only when the underlying concept of interest changes?
- *Responsiveness to change* – Does the measure change quickly when the underlying concept of interest does?
- *Ease of understanding* – Is the measure easily explained and understood?
- *Economy of collection* – How much additional cost is required to calculate the measure on a quarterly basis?
- *Balance* – Are the measures as a group balanced (e.g. long-term vs. short-term)?

Criteria for setting effective performance targets are:

- Targets should require extra effort but not be debilitating.
- Three-year targets can be most aggressive.
- Each year, focus on breakthroughs in one or two key areas (depending on the areas' value, the magnitude of the potential improvement, timeliness, energy and enthusiasm for the area, available skills within the organization, and information on best practices).
- Communicate the importance of achieving targets.
- Go outside your industry in looking at best practices.

To integrate performance measures into daily management, the authors recommend focusing on four goals:

- Make the measures a regular part of the management process.
- Set a limited number of priorities.
- Involve as many people as possible in the regular review process.
- Review measures regularly with the Board or other governing group within the organization.

The authors discuss several "new challenges in the business environment" that are changing the focus of organizational management, the "competitive advantages" that result from the those challenges, the emergence of knowledge-based business, management's lack of confidence in non-financial performance measurement (partly due to disagreement on chosen measures and failure to update them), obstacles to successful measurement management, tools for building a measurement-managed business, data management techniques, and "red flags" to watch out for.

Comments: The book is worth a second reading. Some particularly thought-provoking excerpts are the following:

- "When we began to question managers about the department's measurement system, we found managers were tracking no less than 150 separate performance measures. Only an IT department has the capability to indulge in that kind of excess! The result was a plethora of unfocused, misdirected activities. Every manager in the department had selected a completely different subset of measures that he or she was trying to optimize. No two managers had the same set of top priorities. Not one measure represented the viewpoint of customers."
- "...Good measurement involves a qualitative component."
- "A myth exists that a 'hard' measure such as 'percent turnover' is always better than a softer measure like a survey.... The most effective measurement systems have a blend of 'hard'

measures and survey or other perceptual measures. The perceptual measures are typically the most sensitive leading indicators of change, while the hard measures serve to make sure the actions guided by the perceptions are ultimately successful."

- "Simply allowing a customer to voice a complaint significantly increases the likelihood of repeat business."
- "If you ask people about a subject, they are likely to conclude that you think it is important and that you are willing to address gaps or issues in this particular area."
- "...Approximately 50 percent of those organizations setting out to implement major changes in their measurement system feel the effort was less than fully successful."

Schoon, John G., Michael McDonald, and Adrian Lee

"Accessibility Indices: Pilot Study and Potential Use in Strategic Planning"
Paper 00-0570, presented at the Transportation Research Board 79th Annual Meeting
Transportation Research Board, Washington, D.C., January 2000

Context: Estimation of accessibility indices for transit and private vehicles

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Study in southern England (Hampshire and Surrey)

Service Contracting Addressed? No

Performance Measures Identified:

- *Community-based:* Equity in the accessibility of different locations
- *Transit availability:* Accessibility index based on transit service coverage and availability, travel time, frequency, equivalent doorstop frequency
- *Speed & delay:* Access time

Summary: In this paper, the authors discuss the development of accessibility indices for transit and for private automobiles based on door-to-door travel times and costs. The authors define accessibility as "the ease and convenience of reaching some destination," and they note that equity in the accessibility of different locations should be an important feature of the transportation system. Transit accessibility is affected by travel times, travel costs, geographical transit coverage, frequency of transit service, safety, security, travel comfort, reliability, and transit service availability throughout the week and day.

The authors' approach to developing accessibility indices included the following calculations and assumptions:

- Travel time estimates were based on the distances, speeds, and access times for door-to-door trips. Bus trips included walking times and waiting times.
- The total cost for transit was equivalent to the fare. The cost for private vehicles was based on average operating cost and parking cost and adjusted by average vehicle occupancy for per capita comparison with transit cost.
- The accessibility index for car travel time is:

$$\frac{Time\ by\ Car}{\frac{1}{2}(Time\ by\ Car + Time\ by\ Bus)}$$

The accessibility index for bus travel time is

$$\frac{Time\ by\ Bus}{\frac{1}{2}(Time\ by\ Car + Time\ by\ Bus)}$$

- Travel cost indices were calculated in the same manner as the travel time indices.
- Data collected for the authors' pilot study focused on work trips during the a.m. peak period.

- For the transit indices, the distance between the origin and the bus stop was measured along the nearest streets. (Bus riders always walked to and from bus stops.) Selected O-D pairs were all located within 0.4 km of a bus stop. Assumptions about walking speed, the distance from the bus stop to the destination, and wait time are described in the paper.
- For the automobile indices, travel distances were measured along roadways using average running speeds appropriate to the type of roadway facility. Assumptions about the distance between origins, destinations, and parking facilities and about parking time are described in the paper.
- Details about the calculation of out-of-pocket operating cost are also described in the paper.
- It was assumed that bicyclists used the same corridors as automobiles and maintained an average speed of 14 kilometers per hour. Five minutes was added to allow for walking time between the bicycle rack and the destination.

"Unique" characteristics of the authors' indices are:

- They measure door-to-door trips between origin-destination pairs.
- Transit and other modes are directly compared.
- They are not weighted and are directly related to travel time and costs.
- The basic formulation is valid when accessibility is measured by distance and cost.
- Equity is considered.

Non-quantifiable influences recognized to affect ridership include:

- Presence of sidewalks and pedestrian crossings to and from bus stops and stations
- Waiting facility characteristics
- Bicycle priority features and bicycle storage

Comments: The transit indices developed by the authors are "related directly to travel time and costs, with no weighting or other features that might complicate their understanding by non-technical people." This means that the more subjective components of transit quality of service (such as bus reliability and the inconvenience of transfers) were not accounted for, and the impacts of policy changes on mode splits may be overestimated as a result. The decision not to include such intangible parameters is clearly stated in the report; it was not overlooked, and general observations of such parameters were made. However, a penalty was applied at "known congestion points" in the calculation of the automobile indices, so there is some inconsistency in the modeling of the intangible parameters.

The authors did not use straight-line distances between origins, destinations, and bus stops. This is a good feature of their indices. It is also consistent with their aim of minimizing the use of average values, weights, and generalizations.

The bicycle indices were not developed with the level of detail used for buses and cars.

It is not clear whether the study methodology can be easily applied to a large transit system. The paper does not state how much data were collected and how inputs were measured.

The authors state that their indices "can be presented in simplified graphical fashion to inform non-technical audiences."

Simon, Rosalyn M.

"Paratransit Contracting and Service Delivery Methods"
Synthesis of Transit Practice 31
Transportation Research Board, National Academy Press, Washington, D.C., 1998
http://nationalacademies.org/trb/publications/tcrp/tsyn31.pdf

Context: Overview of operational practices that transit agencies use to provide paratransit service, particularly with how agencies grapple with the issue of providing cost-efficient and effective paratransit service, while meeting the standards of the ADA.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☒ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: Urban demand-response (general public and specialized), rural demand-response (specialized)

Service Contracting Addressed? Yes

Performance Measures Identified:

- *Comfort & convenience:* Curb-to-curb versus door-to-door demand-responsive service
- *Service delivery:* Performance incentives and penalties to contractor, complaint procedures, performance monitoring
- *Service offered/utilization:* Driver training
- *Economics/productivity:* Service efficiency ratings

Summary: *Paratransit Contracting and Service Delivery Methods* does not focus on service quality standards. It is concerned about the different organizational structures used by the surveyed transit authorities to meet the requirements of the ADA. Transit agencies' struggles between quality and efficiency are often illustrated in the responses to the surveys that are provided by the author.

Large transit agencies considered control over the quality of service and demand management as equal in importance to the benefits of cost savings that could be potentially realized by privatization. The study notes that the use of private providers to deliver paratransit service has grown primarily due to cost considerations, although responsiveness (a definite quality issue) was also cited. What agencies meant by responsiveness was vehicle availability and the ability to respond to increases in service demand.

The study also touches on what the effective organizational structure can have on quality. An agency that directly operates paratransit service must focus on the measures that its service provides while those that contract out must use somewhat different tactics. Those contracting out use a variety of oversight and incentive strategies designed to ensure that the operation is effective and efficient. Contracting out paratransit service does not remove the transit agency's responsibility to provide service; ensuring its effectiveness and quality requires a significantly different approach than a service that is directly operated.

The study is what it purports to be: a general survey of contracting methods and service delivery in the late 1990s. The limitations of the paper and the need for additional study were cited in the conclusion, and they include the fact that quality issues were only reviewed from the agency's perspective and not the customer's perspective.

Comments: This synthesis touches upon some of the unique challenges that agencies face in providing ADA service. Controlling costs is often a driving factor that will override other considerations. Implicit in the survey was that large transit agencies conceded some control and perhaps quality to allow private contractors to provide paratransit service at a lower cost. *Developing performance indicators that are workable must consider these tradeoffs and pressures.*

Simpson, Curtin, and the University of Pennsylvania

Transit System Performance Evaluation and Service Change Manual
U.S. DOT, Washington, D.C., 1981

Context: This document was written to help Pennsylvania State DOT systems create and use performance measures and performance standards.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None. A hypothetical transit agency is used to demonstrate the process of establishing goals, performance standards, and measures.

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? No

Performance Measures Identified:

- *Comfort & convenience:* Number of customer complaints
- *Service delivery:* Miles between road calls
- *Service offered/utilization:* Vehicle load factor
- *Economics/productivity:* Revenue versus cost (system-wide and by route), percent of annual budget increase versus industry wide increases, ratio of operating employees to administrative staff, kilowatt-hours per square foot in system facilities, fuels used per square foot of fixed facility, miles per gallon, miles per quart of oil, annual vehicle miles/vehicle hours per employee, vehicles per mechanic, platform hours per driver pay hour, vehicle hours per peak period vehicle, revenue miles per revenue hour, accidents per 100,000 vehicle miles, operating cost per passenger, subsidy per passenger, annual passengers per service area population, revenue passengers per vehicle mile/per vehicle hour, percent increase in riders per vehicle mile of service, user charge per mile

Summary: This paper presents a detailed, step-by-step process by which Pennsylvania transit operators can design and implement a performance measurement and standards system. First, the agency must translate its overall system goals into more specific objectives, such as “maximize revenue passengers per vehicle hour.” Once such objectives have been set, they should be translated into specific, quantitative performance levels that would satisfy each objective. To use the same example, a performance level for the objective “maximize revenue passengers per vehicle hour” would translate into a figure like a system-wide average of 30 passengers per vehicle hour.

The report outlines six areas of performance objectives: system efficiency, system effectiveness, system utilization, fare policy, management, and marketing. Within each objectives category, the report defines two or three performance levels to be achieved. After such performance objectives and standards have been set, then operators can come up with specific measurements that allow them to gauge their progress in meeting their performance standards. The report gives performance measurement examples for each performance standard discussed above.

Comments: This report was specifically written for Pennsylvania DOT systems, but is a straightforward, step-by-step document that could easily be used for any system looking to implement performance standards and measurements.

Smith, Nancy J., and Marjean Drost

Getting There: Bridging the Transportation Gap for Older Adults
Proceedings of the 2001 Bus and Paratransit Conference
American Public Transportation Association, Calgary, Alberta, 2001

Context: This paper was written to document the methods and findings of a transportation summit aimed at facilitating and improving coordination of services in a large metropolitan area in order to better serve the existing population of older adults and the projected growth of the older adult population.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☒ Market research
- ☐ Performance reporting
- ☐ Applications of technology
- ☒ Other: <u>User/stakeholder input in defining service/performance effectiveness</u>

Transit Systems Evaluated: Denver Regional Transportation District, Rose Community Foundation

Transit Modes Considered: Urban fixed-route bus, urban demand-response (specialized)

Service Contracting Addressed? Yes

Performance Measures Identified:

- *Community-based:* Identifies measures of performance that are a result of community input
- *Transit availability:* Identifies gaps in adequate services to meet the needs of older adults, including accessibility of information about services and existing resources

Summary: This paper identifies a new template for facilitating transportation coordination and improvement in a large metropolitan area. The Committee on Aging at Rose Community Foundation (RCF) in Denver, Colorado, sponsored a transportation summit of local transportation providers in order to address transportation issues as they relate to the older adults market. Transportation providers were concerned about the projected growth of the older adult population and how to proactively prepare for the transportation issues involved in serving that population. The transportation summit identified some activities as vital to an ongoing coordination process. The transportation summit included focus groups consisting of transportation providers, funders, riders or potential riders, and those providing other services or caring for older adults. From the input of the focus groups, the summit identified significant issues that fall into three major categories: fragmentation in services, personal choices involved in an individual's personal decision to stop driving, and communications, politics, and jurisdictional issues among providers. The leadership role taken by the foundation as not only a funder but also the facilitator of dialogue and action enabled significantly more progress to be made. Some future activities for the region are also presented.

Soyode, Afolabi

Performance Measurement and Control in Public Transit Authorities
A Dissertation in Business and Applied Economics
University Microfilms International, Ann Arbor, Michigan, 1973

Context: This dissertation was written to explore the use of fiscal accounting data as a useful performance measure in non-profit public transit systems.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Southeastern Pennsylvania Transportation Authority (SEPTA), New York Port Authority (NYPA).

Transit Modes Considered: Urban fixed-route bus, light rail, heavy rail, commuter rail

Service Contracting Addressed? No

Performance Measures Identified:

- *Service delivery:* Vehicle-miles, passenger-miles, percentage of fleet idle, vehicle breakdown rate
- *Service offered/utilization:* Number of passengers, passengers per unit time, mileage per vehicle
- *Economics/productivity:* Cost per vehicle mile, cost of administrative staff to operational staff, cost per passenger, revenue per vehicle mile, revenue per passenger, revenue riders per capita, percent of net operating revenue to gross revenue, operating expenses as a percentage of gross revenue, variance analysis, operating income versus operating expense

Summary: This dissertation is divided into two sections: a theoretical analysis of fiscal efficiency maximization in transit organizations and a case study of SEPTA, which ostensibly seeks to apply these theoretical findings to an actual transit system. However, there is little overlap between the two sections. The first section examines the role of economic performance measures such as cost per vehicle mile, revenue per passenger, etc. These measures are discussed within a "systems theory" context, which seeks to create general equations for maximizing the efficiency of said measures. The result is a general list of possible fiscal performance measures with only loose connection to their actual feasibility or usefulness within a transit organization. This is made more apparent in the case study of SEPTA, which reads more like a history of the organization and includes little analysis or discussion of how fiscal performance measures are used in the system.

Comments: This dissertation is primarily an academic exploration of fiscal efficiency maximization. It is mostly theory-based and offers little practical insight for transit systems.

Strategic Rail Authority

On Track, Edition 3 (15 Oct - 31 March 2001)
http://www.sra.gov.uk/sra/ontrack/Default.htm
Strategic Rail Authority, UK, June 2001

Context: Public information on UK rail operators' performance

Applicability to G-6 Project:
- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Twenty-five train operating companies (TOCs) in the UK

Transit Modes Considered: Commuter and intercity passenger rail

Service Contracting Addressed? Yes

Performance Measures Identified:
- *Community-based:* National Passenger Survey on 12 aspects of train travel; complaints per 100,000 passenger journeys; response to complaints within target and within 20 working days; actions to improve service to customers (outside franchise agreement)
- *Economics/productivity:* The incentive payments/penalties for each TOC (based on punctuality, short formations, and timetable changes [See Comments below for more details]); subsidy per passenger mile
- *Speed & delay:* Percentage of trains 0 to 5 minutes late (includes early trains), 5 to 10 minutes late, 10 to 15 minutes late, 15 to 20 minutes late, over 20 minutes late, and cancelled (if run less than half of the route), measured at final destination

Summary: This is a bulletin for the public that reports the performance of the individual TOCs, comparing the measures to the same times in the previous years and the preceding periods.

There are three types of incentive payments/penalties for each TOC. One is based on punctuality in which lateness and cancellations are compared to the benchmark figure (which is the annual performance in the pre-franchise period in most cases). If the performance is better than the benchmark, the SRA pays the operator, otherwise the operator pays the SRA. Short formation incentive payments apply to peak services in London and some other cites based on cancellation changes to the train plan showing the capacity to be delivered. Timetable change incentive payments penalize operators who change the timetable from the printed version.

Passenger complaints data were divided into a number of categories: train service performance; fares, retailing and refunds; quality on train; information at station and on trains; complaints handling; staff conduct and availability; station quality; other; safety and security; NRES; timetable and connection issues; special needs; and praise comments.

The National Passenger Survey was divided into the following aspects:

1. Overall satisfaction with the journey
2. Trains arrive and depart on time
3. Frequency of trains
4. Price/value for money of tickets
5. Information provided at stations about trains' times/platforms
6. Upkeep and repair of the train

7. Speed of the journey
8. Having a seat
9. Train connections
10. Comfort of the seating area
11. Being able to buy a ticket easily and quickly
12. Providing an appropriate environment for people to catch their train
13. Provision of information if there are any delays
14. Passengers' concerns with personal security
15. Satisfaction with the way in which any recent complaints or claims made for compensation were handled

Comments: It is a good reporting tool. However, it is not very easy to read because there is not enough explanation; it is mostly just tables and figures.

Strategic Rail Authority

Quarterly Bulletin, Edition 3 (17 Oct 1999 to 8 Jan 2000)
http://www.sra.gov.uk/
Strategic Rail Authority, UK, March, 2000

Context: Public information on UK rail operators' performance

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology
- ☐ Other: ____________________

Transit Systems Evaluated: Twenty-five train operating companies (TOCs) in the UK

Transit Modes Considered: Commuter and intercity passenger rail

Service Contracting Addressed? Yes

Performance Measures Identified:

- *Speed & delay:* Grading system based on punctuality and reliability (see Comments)

Summary: This is a bulletin for the public that reports the performance of the individual TOCs, comparing the measures to the same times in the previous years and the preceding periods. It duplicates some of the information in *On Track*, also by the Strategic Rail Authority (SRA)—for example, reliability and punctuality. However, this bulletin also includes a grading system based on these measures.

According to Charter performance over the last 12 months, each route group is assigned a grade for punctuality (on-time percentage), a grade for reliability (% of trips where at least half the scheduled mileage was run), and an overall grade, which is the lower of the two. (See the table below for the grades.) Whole operator performance is graded in the same way by aggregating performance across the total number of that operator's trains that are covered by Charter. Some route groups are excluded from the grading tables as they operate to tighter punctuality standards than the other route groups.

Grade	% Punctuality	% Reliability
A	95 to 100	99.5 to 100
B	90 to 94.9	99 to 99.4
C	85 to 89.9	98.5 to 98.9
D	80 to 84.9	98 to 98.4
E	79.9 or less	97.9 or less

Generally, statistics are based on all trains Monday to Saturday. However some London commuter operators measure all trains Monday to Friday, and there are other exceptions. The franchise agreements require that all operators must carry out at least one customer satisfaction survey every six months.

Comments: It is a good reporting tool, but not very easy to read because there is not enough explanation—it is mostly just tables and figures.

Strathman, James G., et al.

"Automated Bus Dispatching Operations, Control, and Service Reliability: Baseline Analysis"
Transportation Research Record 1666
National Academy Press, Washington, D.C., January 1999

Context: Service reliability analysis of the impacts of a new computer-aided bus dispatching system

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Tri-Met (Portland, OR)

Transit Modes Considered: Urban fixed-route bus, urban demand-response (specialized)

Service Contracting Addressed? No

Performance Measures Identified:

- *Transit availability:* Headway ratio, run time ratio
- *Service delivery:* Arrival delay, excess wait time (an indicator of reliability, not delay)

Summary: The authors of this paper analyzed the service reliability effects of Tri-Met's new computer-aided bus dispatching system (BDS). Their analysis is intended to serve as the baseline study for all phases of BDS implementation. Part of the study included an on-board survey of perceived reliability.

The authors identified four service reliability indicators based on running time, headway, and on-time performance that address both operator and rider perspectives. The reliability indicators were selected according to the following criteria:

- Measures should be self-evident and easy to understand.
- Measures should allow comparison within and between routes.
- Measures should be comparable with other measures used.
- Measures should retain as much information as possible (e.g., they should be continuous rather than categorical.)

Running time is the travel time between an origin and a destination. In this study, it is the travel time between route endpoints. The service reliability measure that the authors have associated with running time is the Run Time Ratio, which is the ratio of observed run time to scheduled run time, multiplied by 100.

Headway is the difference in arrival time between consecutive buses. The service reliability measure associated with headways is the Headway Ratio (HR), which is the ratio of observed headway to scheduled headway, multiplied by 100.

On-time performance is the probability that a bus will be at a stop when it is scheduled to be there, within some time window. This time window typically ranges from one minute before the scheduled departure time to five minutes after the scheduled departure time. The service reliability measure associated with on-time performance is Arrival Delay, which is the difference between the scheduled arrival time and the actual arrival time. (With time windows taken into consideration, the on-time percentage can be calculated.)

The fourth indicator is Excess Wait Time (EW), which is average wait time at a stop outside of time windows. It is expressed as:

$$EW = \frac{Variance\,HR \div 2 \times Mean\,HR}{100} \times Mean\ Observed\ Headway$$

Additionally, the authors define make use of the coefficients of variation for Run Time Ratio and Headway Ratio to represent the variability of run time and headway across time and distance. (The coefficient of variation for an indicator is the ratio of its standard deviation to its mean.) They found that, for the study routes, the coefficients of variation for run time and headway are negatively correlated with on-time performance and positively correlated with each other.

The authors concluded their study of service reliability with the development of service reliability models for Arrival Delay, Headway Delay, Run Time Delay, and Probability of On-time Arrival at the Destination. The independent variables in these models included departure delay at the origin, route length, total passenger boardings, total passenger alightings, scheduled headway, scheduled run time, and dummy variables to account for the peak direction. From the models, they found that delay varies with the number of stops and longer routes tend to experience greater delay than shorter routes.

Comments: In explaining the difference in service reliability between the current study and a 1991 study, the authors claim that "performance generally deteriorates along a route's time points [and] the present study's focus on destinations probably captures worse-than-typical outcomes." This is an interesting supposition, but it was not verified because arrival and departure data were collected only at route endpoints.

It is interesting that the authors do not consider on-time performance a "service reliability indicator" when several other authors and agencies use it that way.

Stuart, Darwin G.

"Goal-setting and Performance Measurement in Transportation Planning and Programming"
Journal of Public Transportation, Winter 1997, Volume 1, No. 2, pp. 49-72
Center for Urban Transportation Research, Tampa, FL, 1997

Context: Stuart's document explores the role of a more systematic application of transportation goals and objectives and associated performance measures.

Applicability to G-6 Project:
- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: New York Department of Transportation, FTA, Ann Arbor Transportation Authority

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified:
- *Community-based:* Passenger trips per capita
- *Transit availability:* Vehicle trips per capita
- *Service delivery:* Vehicle miles between road calls, vehicle miles between accidents, passenger trips per capita, vehicle miles per capita, vehicle miles per service, miles per vehicle
- *Service offered/utilization:* Passenger trips per mile, passenger trips per hour
- *Economics/productivity:* Ridership per expense, passenger trips per employee, vehicle miles per employee, cost per mile, cost per hour, cost per vehicle, cost per passenger trip, revenue per passenger trip
- *Speed & delay:* Average speed

Summary: In the transit planning arena, process-oriented measures have been defined as "service input," with the notion of efficiency defined as more of an internal measure describing how well factors such as labor, equipment, facilities, and fuel are utilized. Product-oriented goals, on the other hand, address externally directed transit performance in terms of effectiveness in meeting the expectations of users and non-users of transit services. Here, goals are often set for meeting overall community transportation needs. Such needs can vary widely according to the size and density of communities served, the network coverage and peak/off-peak service frequency associated with such development patterns, and the resultant quality of service. Effectiveness and product-oriented goals can quickly become complex.

In this paper, Stuart reviews the state of the goal development process in the areas of highway planning, transit planning, and multimodal planning/programming. The growing complexity of goal set development and measurement offers the opportunity for the public transit community to articulate and measure more of the impacts that public transit can have in a community.

In the transit planning arena, the author briefly discusses the Multiattribute Utility Theory utilized by the Ann Arbor Transportation Authority to assist the agency in their decision making process. This approach is a hierarchical model that helps the agency determine whether a specific transit improvement meets the three basic goals of the transit system: satisfying transit customers, being technologically implementable, and being financially affordable.

Stuart, Kenneth R., Marc Mednick, and Johanna Bockman

"A Structural Equation Model of Customer Satisfaction for the New York City Subway System"
Paper 00-0988, presented at the Transportation Research Board 79th Annual Meeting
Transportation Research Board, Washington, D.C., January 2000

Context: Development of a structural model for the measurement of customer satisfaction

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology
- ☒ Other: Model development

Transit Systems Evaluated: MTA-New York City Transit

Transit Modes Considered: Heavy rail

Service Contracting Addressed? No

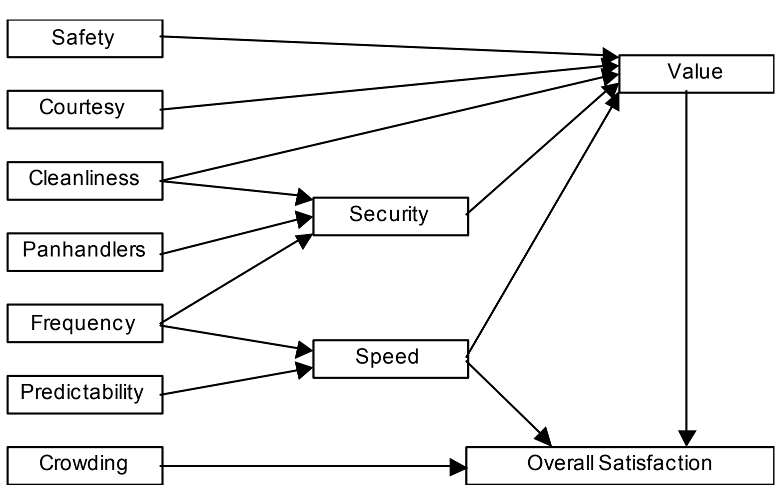
Performance Measures Identified:

- *Comfort & convenience:* Customer satisfaction (includes value for the money, speed of service, personal security, safety from accidents, courtesy, cleanliness, presence of panhandlers, frequency of service, predictability of service, and crowding)

Summary: The objectives of the study were to:

- Develop a model that more completely describes causal factors in customer satisfaction studies
- Determine quantitative measures of the strength of the relationships between the factors
- Describe future uses for the model

The authors used survey data in which riders assessed the NYC subway in terms of the quality of service variables identified above. The authors' preliminary model of causal relationships between these variables is shown in the figure below. This model shows how some service variables are both dependent and independent, influencing overall satisfaction in multiple ways.



The findings of the study are:

- Each of the data paths shown in the figure above is statistically significant, which means that each has an effect on overall satisfaction.
- The impact of predictability on perceived speed is more important than the impact of frequency on perceived speed. The authors claim that this was never quantified before.
- The factors in customer satisfaction can be broken down and examined, and the strength of the relationships between these factors can be quantified and compared.

Talley, Wayne

"A Comparison of Two Methodologies for Selecting Transit Performance Indicators"
Transportation, pp. 201-210
Martinus Nijhoff Publishers, Dordrecht, Netherlands, 1986

Context: This paper was written to compare and contrast two separate methodologies for selecting transit performance measures.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified:

- *Transit availability:* Percent population served
- *Service delivery:* Energy per passenger, annual vehicle hours per employee, annual vehicle hours per vehicle
- *Service offered/utilization:* Passengers per service area of population, passengers per vehicle hour
- *Economics/productivity:* Cost per vehicle hour, revenue per dollar of cost

Summary: This article presents a critical analysis of two separate transit performance evaluation methodologies. The first methodology determines the specific performance measures based upon clearly defined system goals and objectives. Efficiency, effectiveness, and community-based goals are the overriding objectives used to determine the evaluation criteria used in this first methodology. The second methodology examined in this article attempts to assist transit agencies in improving system-wide efficiency by maximizing the use of existing resources. The basic difference between the two methodologies is that the first "requires the specification of indicator selection criteria and the other requires the specification of transit operating objectives for selection of transit performance indicators." The author concludes by stating his preference for the second methodology because it is more robust, more comprehensive, and easier to understand than the first methodology discussed.

Talley, Wayne K., and A. Jeff Becker

"A Single Measure for Evaluating Public Transit Systems"
Transportation Quarterly, Volume 36, Number 3, pp. 423-431
ENO Foundation for Transportation, Inc., Westport, Connecticut, July 1982

Context: Journal article about proposed new performance measure

Applicability to G-6 Project:
- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified:
- *Service offered/utilization:* Transit deficit per passenger
- *Economics/productivity:* Transit deficit per passenger

Summary: The authors propose a single measure—transit deficit per passenger—for transit performance evaluation, because a single measure is easier to understand by both agency staff and the public. Transit deficit per passenger is an effectiveness and efficiency performance measure that:

- measures positive contributions rather than minimum standards
- allows agencies to weight trip types for evaluations of equity and externalities
- assesses a range of potential service improvements
- allows comparison of improvements with "the best available alternative"

Transit deficit is defined as the difference between ridership cost and ridership revenue. There are two aspects to the transit deficit per passenger measure: the actual deficit per passenger of an existing or proposed service and the maximum allowable deficit per passenger. The first aspect is useful for ranking services and/or service proposals. The second is useful for (1) identifying routes that should be considered for termination and (2) providing an upper bound on ridership maximization efforts (e.g., increasing service frequency until the maximum allowable deficit per passenger is reached).

The authors compared transit deficit per passenger to other performance measures (specifically operating ratio, route passengers per mile, and route passengers per hour) to demonstrate that the other performance measures do not consistently identify the "best" route. This is partly because deficit per passenger covers ridership, revenue, and costs—three aspects of service—while other measures are typically more limited in focus.

Comments: This measure allows direct comparison of fixed-route and demand-responsive services. Because it does not pinpoint specific problems and their causes, it appears to be most useful in its route-level ranking and flagging functions.

Real-world examples would have been a welcome addition to the paper. The "hypothetical route" comparison is actually limited by the simplicity of the transit deficit per passenger calculation.

The authors define "transit performance criteria" as the variables that a transit agency can control. This definition seems to be very operator-oriented. The definitions of efficiency and effectiveness also seem to reflect primarily the operator perspective.

Talley, Wayne K., and A. Jeff Becker

"On-time Performance and the Exponential Probability Distribution"
Transportation Research Record 1108, pp. 22-26
Transportation Research Board, National Research Council, Washington, D.C., 1987

Context: Paper sponsored by TRB Committee on Bus Transit Systems

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Tidewater Transportation District (five Virginia cities)

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? No

Performance Measures Identified:

- *Service delivery:* On-time performance

Summary: The purpose of the authors' research was to investigate the measurement of on-time performance from a more rigorous statistical perspective than addressed in previous research. This purpose originated in a 1986 survey that concluded:

- There is wide variation in the definition of on-time performance.
- Determination of on-time performance seems to be mostly informal, with little statistical basis.
- On-time performance is an important service characteristic.
- Research into on-time performance is strongly supported.

The authors found that the distribution of late and early intervals between actual and scheduled intervals followed the exponential probability distribution and that, with determination of an acceptable "failure rate," this could be used to identify routes with substandard on-time performance. The probability distribution is expressed as "the probabilities that buses (or percentage of buses) on a particular route and arriving at a particular bus stop will be more than x minutes early and more than y minutes late." Early arrivals and late arrivals were analyzed separately to avoid negative values in the specification of x and y.

The authors identify one problem with the methodology: classification of buses that are actually on-time. On-time buses can be included in the sample of early arrivals, in the sample of late arrivals, or in both. Alternatively, bus arrivals could be measured in units shorter than one minute (the typical unit for assessing on-time performance). The authors intend to address this issue in future research.

TAS Partnership Limited

Quality Bus Partnerships –- Good Practice Guide
http://www.tas-passtrans.co.uk/qbp-gpg.htm
TAS Partnership Limited
Department of Environment, Transport, and the Regions, UK, 2001

Context: A guide developed to assist local authorities and bus operators in developing and implementing Quality Bus Partnerships (QBPs). The guide is being produced and published by TAS but has been written on behalf of and approved by the Department of Environment, Transport, and the Regions, UK.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? Yes

Performance Measures Identified: No specific measures listed

Summary: Monitoring of QBPs should be conducted to:

- Determine when, whether, or by what degree the objectives of the QBP have been met
- Demonstrate to partners that the QBP process is, or is not, likely to deliver its objectives at intervals during the process
- Demonstrate the impact of the QBP on other objectives and policies
- Develop or alter the strategy, or the mix of components, adopted following the implementation of a scheme, but prior to the development of further schemes

Monitoring seeks constantly to test that the resources being applied to the QBP by the partners are delivering the objectives envisaged. Items to be monitored should directly relate to one of three categories:

- QBP's objectives (this in turn should dictate that targets are monitored)
- Impact of the QBP on other objectives and policies
- Performance of individual components within QBP schemes

Individual items to be monitored should represent the best balance of:

- Those items which best determine outcomes
- Those items which are easiest to determine (i.e., require the lowest level of additional resources)
- The extent to which partners need to monitor and why should monitoring be conducted

Partners should therefore seek to make the best use of data they already collect. This might include:

- Electronic ticket machine data (for monitoring patronage, revenue, and indicative journey time changes)
- Local authority traffic counts (for an indication of reduction of non-bus trips—changes to mode split which might indicate a mode shift); traffic counts are only likely to be appropriate for a large

scheme (probably with spending greater than £5 million) where significant changes are anticipated

Normally, additional surveys will need to be undertaken. Monitoring should be conducted jointly by all partners, with information and results shared. Protocols for data sharing between partners must be agreed to before the start of monitoring. Monitoring may be:

- *Continuous or trend-based* – This gives the best results but will require a much greater level of additional resources if not already collected.
- *Snapshot-based* – Results at one point in time

Comments: The paper discusses generic concepts fostering Quality Bus Partnerships (QBP). No specific performance measures are listed; however, some general comments on monitoring are possibly relevant.

Taylor, Brian

"Program Performance Versus Transit Performance: Explanation for Ineffectiveness of Performance-Based Transit Subsidy Programs"
Transportation Research Record 1496, pp. 43-51
National Academy Press, Washington, D.C., 1995

Context: This paper was written to examine the effectiveness of various state performance-based transit subsidy programs.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: The paper does not evaluate transit systems; it focuses on transit performance measure funding programs in 16 states, with the most attention dedicated to California, Pennsylvania, and Michigan.

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified: None

Summary: This paper is more of an academic exercise in evaluating the equity and effectiveness of statewide performance-based funding allocation programs for mass transit, than an examination of specific transit performance evaluation programs. The author is particularly concerned with the distributional equity associated with these programs. In fact, the author concludes that there is an overall lack of distributional equity and programmatic effectiveness in allocating state funds to the transit systems that actually perform well. Instead, these state programs often reward systems for underperforming because they are "in the greatest need." Alternatively, the amount of money that is contingent upon a transit system's performance is often insufficient to provide an incentive to significantly improve performance. The author concludes that these statewide programs have failed to significantly improve transit performance and should be overhauled or eliminated.

Comments: It should be noted that the author used several different approaches in evaluating the effectiveness of these statewide programs, including a consideration of operator equity, geographic equity, fiscal equity, passenger equity, statewide benefits, and the revenue generating ability of local governments.

Texas Transportation Institute

Urban Mobility Study, Keys to Estimating Mobility in Urban Areas
Texas Transportation Institute, College Station, TX, 2001

Context: This report is additional information in support of the annual (in this case, Year 2001) Urban Mobility Study completed by Texas Transportation Institute in cooperation with 11 state departments of transportation.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: All, generally

Service Contracting Addressed? No

Performance Measures Identified:

- *Speed & delay:* Travel rate, Delay rate, Relative delay rate, Delay ratio, Corridor mobility index, Travel rate index, Reliability factor, Accessibility, Travel delay, Congested travel, Congested roadway

Summary: From the report's summary:

> "There are several keys to developing and applying mobility measures that are technically useful and generally understandable. Travel time measures are relatively easy to comprehend, but they have not always been used because of data concerns, mandated reporting practices, and other issues. Travel time and speed measures can serve many different uses, communicate to many different audiences and enhance the ability of project analysis techniques to determine the most appropriate set of policies, programs and projects for a situation. This report outlines many important mobility measurement concepts."

The overriding conclusion from any investigation of mobility measures is that there is a range of uses and audiences. No single measure will satisfy all the needs, and no single measure can identify all aspects of mobility—there is no "silver bullet" measure.

Comments: This document was completed to provide information regarding mobility measures and how to develop and use them in estimating mobility in urban areas. The document attempts to provide elected officials, policy makers, and everyday commuters a collection of easily understood measures to support local decision-making related to freeway and street systems as well as a variety of other land-use issues.

Thakuriah, Piyushimita, and Paul Metaxatos

"Effect of Residential Location and Access to Transportation on Employment Opportunities"
79th Annual Meeting of the Transportation Research Board
Washington, D.C.

Context: The article discusses the development of a model to estimate the relationship of transportation, location, sociodemographic, and family effects to job tenure. The model created by the authors relates transportation and other factors to job tenure.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Chicago area TANF clients are targeted.

Transit Modes Considered: Urban fixed-route bus, heavy rail, commuter rail

Service Contracting Addressed? No

Performance Measures Identified:

- *Community-based:* Measure of job retention

Summary: Women on public assistance seek to obtain and keep jobs. However, they have special transportation needs. Many do not have access to an auto, so public transit may be the only feasible mode. Also, the jobs for which they are qualified require working during the night or early morning when transit may not be available.

According to the authors, the issue for welfare clients is employment retention, and transportation is a factor that contributes to it. The authors measure job retention by welfare recipients based on a measure of "total employment." It comprises the length of tenure with the same employer over a period of time and the number of jobs held during the same period. The proportional odds model was established to estimate the relation of transportation and other factors to job tenure.

In the model, the transportation factors used were access to a vehicle, possession of a driver's license, and reliance on public transportation. The question "Which residential locations offer welfare clients a comparative advantage?" is answered by examining the number of entry-level jobs within a 'catchment' area of a travel time which is cost-effective for a client to incur at the wage rate that he or she will receive.

The authors note that 100 percent of all entry level jobs in the Chicago metropolitan area are accessible within 90 minutes by car; however, the percent drops to 60 percent for travel by public transportation. This implies that proximity to a job may not help welfare clients if they do not have access to a car.

Two accessibility indices have been created by the authors:

1. Auto travel time along the shortest path to each job destination
2. Fastest mode of transit between each origin and job destination

A location index was also created, based on whether or not an individual client has access to a vehicle.

The results of the Chicago area study show that:

- Female welfare clients with the longest job retention reside in locations where a large number of job openings are accessible within a reasonable travel time and where competition for those jobs from other clients are lower.

- Access to cars, though important, is not as significant as a variable combining the competition for jobs and the number of jobs that can be accessed by a vehicle within 'tolerable' travel time.
- The exact location of a client's residence vis-à-vis job locations is not significant. However, when educational background is taken into consideration, female clients with accessibility and locational advantages exhibit increased job retention.
- As expected, a greater proportion of clients who have greater job retention and employment retention rates have access to a vehicle and a valid license. The authors believe this is due to the fact that a more secure employment situation permits the acquisition of these items.

Comments: This paper highlights the special needs of welfare clients and the role transportation plays in serving those needs. Accessibility to jobs for welfare clients is certainly a community goal and should be measured using appropriate performance indicators.

The authors have decided not to address the needs of some welfare clients to make intermediate stops at day care centers or other locations. These needs may influence the level of accessibility of those welfare clients who have children. Even if a transit route from a client's residence to a job location exists, if the day care center is not accessible by transit, then that job location may not be feasible for this particular client.

Thatcher, Russell, and John Gaffney

ADA Paratransit Handbook: Implementing the Complementary Paratransit Services Requirements of the Americans with Disabilities Act of 1990
U.S. Department of Transportation, Urban Mass Transportation Administration, Washington, D.C., 1991

Context: This handbook was designed to assist agencies in implementing the paratransit service requirements of the Americans with Disabilities Act.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: Urban and rural demand-response (general public and specialized)

Service Contracting Addressed? Yes

Performance Measures Identified:

- *Community-based:* Public involvement in developing ADA plan
- *Transit availability:* Eligibility, service span, accessibility, information
- *Comfort & convenience:* Reliability, travel time
- *Service delivery:* Missed trips
- *Speed & delay:* Travel time

Summary: The guidebook clarifies the regulations in a manner that attempts to translate how service can be practically implemented. This guidebook was published shortly after the passage of the ADA and issuance of the accompanying DOT regulations.

It is impossible to develop any performance standards criteria for ADA complementary paratransit without considering the ADA. The ADA is designed to guarantee the civil rights of persons with disabilities. As it relates to transportation, that means that a minimum level of performance or quality is required by transit agencies to be compliant.

Those quality measures necessarily need to be incorporated into any performance standards. There are six basic service requirements for ADA. Some of these required levels of service can be met by being designed into service standards; the others require ongoing efforts. These levels of service are:

- *Service area* – Three-quarter mile corridor around fixed routes; met by service standards
- *Next day response time* – Met by service standards and ongoing measurement
- *Fares* – No more than two times fixed-route fare; met by service standards/fare policy
- *Trip purpose* – No prioritization of trip purpose; met by service standards and monitoring of complaints
- *Hours and days of service* – Met by service standards
- *Capacity constraints*
  - *Denials* – Ongoing measurement
  - *Late pickups* – Ongoing measurement
  - *Missed trips* – Ongoing measurement
  - *Excessively long trips* – Ongoing measurement

The issues surrounding capacity constraints require performance standards to determine if the quality of service mandated by the ADA is being achieved.

The handbook acknowledges that the performance requirements of the ADA do not meet many transportation needs of persons with disabilities and that additional efforts above and beyond the requirements of the ADA are necessary if some of those needs are to met. The ADA is designed to meet the needs of the disabled at the same time the needs of the general public are met. One of the most telling comments regarding transportation services for persons with disabilities is that ADA affords persons with disabilities the right to the same mass transportation service opportunities everybody else gets, whether they be good, bad, or mediocre.

Despite these limitations regarding level of service and other issues, minimum levels of quality dictate certain aspects of what performance standards are necessary for ADA paratransit.

Comments: The experience of transit agencies has shown that most (more than 80 percent) choose to go over and above the ADA regarding service levels. In other words, most agencies have chosen to aspire to a higher level of service quality than the ADA mandates. However, it is also important to differentiate what service is required by the ADA and what quality and level of service is over and above the ADA when making policy choices and developing performance standards.

The Howell Research Group

Arapahoe/Douglas Counties Transit Study: Household Mail Survey, Volumes 1 and 2, Prepared for the Regional Transportation District
The Howell Research Group, Denver, CO, April 2001

Context: Rider survey and transit demand study as part of an update to RTD's transit needs database

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☒ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Denver RTD

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? No

Performance Measures Identified: None

Summary: The purpose of this study was to estimate demand for RTD transit service in Arapahoe and Douglas Counties.

Comments: This technique described in this study can be used to assess how well actual service matches demand for service, but such a survey is more likely to be useful and practical for planning than for monitoring.

The Howell Research Group

Regional Transportation District 1995 Customer Satisfaction Survey
The Howell Research Group, Denver, CO, March 1996

Context: District-wide rider survey

Applicability to G-6 Project:
- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☒ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Denver RTD

Transit Modes Considered: Urban fixed-route bus, urban demand-response (specialized), light rail

Service Contracting Addressed? No

Performance Measures Identified: None

Summary: The purposes of the 1993 customer satisfaction survey were to determine:

- Satisfaction with RTD based on "critical performance attributes"
- Priorities for corrective actions or improvements
- Trends in ridership and satisfaction
- Demographic profiles of riders by service type, peak/non-peak boardings, payment type, and trip type

The performance attributes included in the study are listed in table on the following page.

Performance Category	Performance Attribute
Bus comfort	Availability of seats; cleanliness of interiors; smoothness of ride; temperature level; availability of bus stop shelters
Bus convenience	Closeness of bus stop to home; closeness of bus stop to final destination; closeness of a park-and-ride to home; availability of evening service; availability of weekend service
Bus customer information	Accuracy of information provided by RTD Telephone Information Center (TIC); notice of route, schedule, and other service changes; availability of general information about RTD's services and activities; ease of using RTD's automated telephone information system; ease of reaching an RTD TIC operator
Bus driver performance	Driver's appearance; driver's courtesy; driving skills; driver's ability to answer questions about bus service
Bus security	Security on the bus; security at bus stops
Bus travel time	On-time performance; amount of travel time required on bus; required number of transfers; frequency of buses; waiting time when transferring
Light rail comfort	Cleanliness of interiors; smoothness of ride; temperature level; availability of seating
Light rail customer information	Clarity of public address system on trains; ease of understanding light rail/bus connection timetables
Light rail personnel	Driving skills of train operator; courtesy of ticket inspectors
Light rail security	Security on light rail; security at stations/stops
Light rail stations/stops	Cleanliness of stations/stops; protection from elements when waiting
Light rail ticket vending/validation	Sufficient number of machines that validate tickets; reliability of machines that sell tickets; ease of using machines that sell tickets
Light rail transfers	Reliability of bus/light rail connections; required number of transfers from/to buses to reach final destination; time spent waiting for connection between bus and light rail
Light rail travel time	Amount of travel time required on light rail; on-time performance; frequency of trains
Park-and-ride improvements (light rail)	Frequent neighborhood circulator buses; more frequent bus service; increased number of park-and-rides; covered parking; convenient retail services
Park-and-rides (bus)	Walking distance to bus loading area; availability of parking spaces; security
Park-and-rides (SkyRide)	Walking distance to bus loading area; availability of parking spaces; security
SkyRide comfort	Cleanliness of interiors; smoothness of ride; availability of seats; temperature level; cleanliness of bus stop shelters
SkyRide convenience	Closeness of bus stop at Denver International Airport (DIA); closeness of SkyRide stop to home; availability of weekend service; availability of evening service
SkyRide customer information	Helpfulness of RTD service personnel at DIA information booth; accuracy of SkyRide information provided by RTD TIC; availability of general information about SkyRide; notice of route, schedule, and other service changes; ease of using RTD's automated telephone information system; ease of reaching an RTD TIC operator
SkyRide security	Security on the bus; security at bus stops
SkyRide travel time	On-time performance; required number of transfers; amount of travel time required on SkyRide; directness of route to destination; frequency of buses; waiting time when transferring
SkyRide* driver performance	Driver's courtesy; driver's handling of luggage; driving skills; driver's appearance; driver's ability to answer questions about SkyRide service

*Bus service between park-and-rides and the airport

Transperth

Personal Communication with Mr. Ian Vinicombe
Transperth, Perth, Western Australia, Australia

Context: List generated in response to our inquiry on the performance indicators used by Transperth

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Trains—Westrail; ferries—Perth Water Transit; buses—CGEA Connex, Southern Coast Transit, Path Transit, and Swan Transit.

Transit Modes Considered: Urban fixed-route bus, commuter rail, ferry

Service Contracting Addressed? Yes

Performance Measures Identified:

- *Community-based:* Affordability (average concession fare as a proportion of the single pension per day); proportion of service kilometers provided by wheelchair-accessible vehicles; proportion of train stations providing unaided access to people in wheelchairs; passenger information (proportion of incoming calls answered); customer complaints/compliments
- *Comfort & convenience:* Bus fleet presentation (the number of instances where the bus or the driver does not conform to specified standards)
- *Economics/productivity:* Total boardings including transfers; initial boardings (number of journeys commencing on each mode and recorded electronically); initial boardings per service kilometer and per capita; real cost per 1,000 passenger place kilometer; proportion of the Transperth bus fleet conforming to ECE emission standards
- *Speed & delay:* On-time running (proportion of services running within five minutes of the scheduled time)

Summary: The 13 performance indicators used by Transperth in monitoring the transit operators (4 bus, 1 train and 1 ferry) are listed above.

Comments: *From the Transperth website (http://www.transperth.gov.au/) on the system of public transport operation:* The Transperth system comprises bus, train, ferry, and information services and is managed by Transport, Western Australia (http://www.dot.wa.gov.au/), whose annual report was also reviewed for additional information. To make the system more efficient, Transperth has opened these services to tender. Private companies and government organizations compete to run Transperth services, and the successful tenderers are known as Transperth Operators. To win a contract, an Operator must provide the same service at less cost, or a better service for the same cost. Some Operators may even provide a better service at less cost. In the future, all Transperth services will be operating under a contract arrangement.

Transport, Western Australia

Annual Report 1999-2000
Transport (Western Australia), Perth, Western Australia, Australia, 2000
http://www.dot.wa.gov.au/annualrep/rep9900/index.html

Context: Annual report for public information

Applicability to G-6 Project:
- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Public transport operators under Transperth, which is managed by Transport (Western Australia)

Transit Modes Considered: Urban fixed-route bus, commuter rail, ferry

Service Contracting Addressed? No

Performance Measures Identified:
- *Community-based:* Stakeholder and Customer Satisfaction survey (telephone survey ranking of poor to excellent for aspects of the transit system)
- *Comfort & convenience:* Percentage of service kilometers by wheelchair-accessible vehicles in total fleet service kilometers; wheelchair-accessible train stations in total number of stations
- *Service delivery:* Transperth bus fleet conforming to ECE emission standards
- *Service offered/utilization:* Total boardings
- *Economics/productivity:* Percentage of household income spent on transport; average Concession fare as a proportion of the single pension per day

Summary: The annual report for Transport (Western Australia) has a chapter on performance indicators, some of which relate to public transport service provision. A number of the performance indicators listed related to other aspects of transportation (for example, freight).

Comments: The performance indicators are divided into integrated, safe, accessible, environmentally sustainable, efficient, and effective revenue collection.

Tri-Met

Tri-Met Service Standards: "A Commitment to Excellence"
Prepared for Tri-Met, Portland, OR, May 1989

Context: Tri-Met prepared this report to provide themselves with a framework with which to objectively evaluate the quality and efficiency of transit service provision.

Applicability to G-6 Project:
- ☒ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Tri-Met (Portland, Oregon)

Transit Modes Considered: Urban fixed-route bus, light rail

Service Contracting Addressed? No

Performance Measures Identified:
- *Transit availability:* Bus stop spacing
- *Comfort & convenience:* Number of transfers (no more than one transfer should be required to get to downtown Portland from residential areas)
- *Service delivery:* System average schedule efficiency (ratio of revenue hours to vehicle hours)
- *Service offered/utilization:* Boardings per revenue hour
- *Economics/productivity:* Fare recovery ratio
- *Vehicular capacity:* Load factor (passengers on board divided by seating capacity)
- *Speed & delay:* On-time performance, missed trips

Summary: This Tri-Met report documents the various performance measures utilized by the transit agency in evaluating their service provision. The performance measures emphasize service effectiveness more than service efficiency. Absolute service standards are set, such as 75 percent on-time performance or 30 percent fare recovery rate, as opposed to monitoring the system's performance over time and using the performance measures to evaluate the relative performance of the system. The performance measures presented in this report were not integrally linked to clearly defined goals and objectives for the transit system.

Comments: There are several appendices in the back of the report with extensive route-by-route statistics on some of the key performance measures addressed earlier in the report.

United States Department of Transportation

Characteristics of Urban Transportation Systems
Revised Edition
Federal Transit Administration, Washington, D.C., 1992

Context: This document is intended as a sourcebook for transit planners to use when evaluating the design of their system. It consists entirely of tables that report Section 15 (now National Transit Database) average performance measures for rail, bus, automobile, HOV lanes, and automated gateway transit systems.

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: All systems, nationwide

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified:

- *Comfort & convenience:* Accidents per million passenger miles
- *Economics/productivity:* Cost per revenue vehicle mile/revenue vehicle hour, cost per place mile, cost per passenger mile, employees per thousand revenue vehicle miles/revenue vehicle hours, employees per peak vehicle, kilowatt-hours per revenue vehicle mile/revenue vehicle hour, kilowatt-hours per thousand place miles/passenger miles, gallons per revenue vehicle mile/revenue vehicle hour, gallons per thousand place miles/passenger miles, capital costs per route mile, cost per linear root foot, cost of rolling stock, operators per thousand revenue vehicle miles, mechanics per thousand revenue vehicle miles
- *Vehicular capacity:* Square feet per passenger (net)
- *Speed & delay:* Average speed, dwell times, peak hour bus travel minutes per mile

Summary: This paper is strictly a fact book and reference manual, offering no analysis or guidance to transit planners or operators. It is, however, a useful guide for determining which performance measures are in widespread use and recognition at the Federal level.

United States Department of Transportation

The Status of the Nation's Local Mass Transportation: Performance and Conditions
Report to Congress
U.S. DOT, Washington, D.C., June 23, 1989

Context: This report was submitted to Congress in compliance with Federal law that mandates biennial reporting of the status of the nation's public mass transportation systems.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: All systems nationwide, based on Section 15 (now National Transit Database) reporting and industry-wide APTA data gathering

Transit Modes Considered: All

Service Contracting Addressed? Yes

Performance Measures Identified:

- *Service offered/utilization:* Passenger miles per revenue vehicle hour, revenue vehicle hours per capita, route miles per urban area square mile, service per route mile, passenger miles per 1980 urbanized area population
- *Economics/productivity:* Operating costs per revenue vehicle hour, revenue vehicle hours per full-time-equivalent employee, operating costs per passenger mile

Summary: This comprehensive report covers all areas of transit management and operation. This review focuses on Chapter 5, which details the measures used in evaluating the performance of the nation's transit systems.

The report found that, as a whole, operating efficiency declined between the period of 1980 and 1985. This was caused by increased operational costs, as measured by *operating costs per revenue vehicle hour*. Operating costs per revenue vehicle hour rose 16 percent over the five years covered by this report. Declining labor productivity contributed to this trend, as measured by *revenue vehicle hours per full-time-equivalent employee*.

Effectiveness and service utilization also declined during this period. The report used one primary and four secondary performance measures to evaluate this trend. The primary measure used was *passenger miles per revenue vehicle hour*. Secondary measures used to explain this decline *were revenue vehicle hours per capita*, *route miles per urban area square mile*, *service per route mile*, and *passenger miles per 1980 urbanized area population*.

The report used one major performance measure to evaluate the operating cost-effectiveness of the nation's transit service. The report found that operating cost-effectiveness declined 15 percent between 1980 and 1985, as measured by *operating costs per passenger mile*. This resulted in increased operating costs per passenger and per passenger mile.

The chapter concludes by emphasizing the need to improve management and labor productivity, provide incentives for better performance through competition, and to improve the cost-effectiveness of transit systems by involving the private sector more and by tailoring service more directly to market needs.

Wallace, Richard R.

"Paratransit Customer: Modeling Elements of Satisfaction with Service"
Transportation Research Record 1571
National Academy Press, Washington, D.C., 1997

Context: The author wished to see if Advanced Public Transportation Systems (APTS) can impact paratransit customer satisfaction.

Applicability to G-6 Project:
- ☒ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☒ Market research
- ☐ Performance reporting
- ☒ Applications of technology
- ☒ Other: Use of surveys

Transit Systems Evaluated: Detroit-area paratransit service

Transit Modes Considered: Urban demand-response (general public and specialized)
- ☐ All
- ☐ None
- ☐ Urban fixed-route bus
- ☒ Urban demand-responsive transit (general public)
- ☒ Urban demand-responsive transit (specialized)
- ☐ Rural (general public)
- ☐ Rural (specialized)
- ☐ Light rail
- ☐ Heavy rail
- ☐ Commuter rail
- ☐ Ferry
- ☐ Other: ____________________

Service Contracting Addressed? No

Performance Measures Identified:
- *Comfort & convenience:* Phone call response
- *Service delivery:* Travel time, on time for pick up and drop off
- *Service offered/utilization:* Denied trips
- *Speed & delay:* Travel time

Summary: The author states that little effort has been made to gauge the satisfaction level of paratransit customers. With the implementation of APTS by the Suburban Mobility Authority for Regional Transportation (SMART) in the Detroit area, a means was sought to measure customer satisfaction with service. A survey was conducted of paratransit customers who had used the service in the previous six days.

Demographic and service satisfaction questions and the results showed a moderately favorable view of the service. However, the study was very rudimentary in looking at elements of performance standards for paratransit.

The survey from the view of customer service missed critical areas. Ability to get a trip at the time desired, ability to obtain long-term (subscription) service, responsiveness to complaints, and vehicle comfort and cleanliness are additional areas critical to paratransit customers.

Comments: The survey did not address some of critical elements of customer service and satisfaction for paratransit riders. Questions regarding trip availability at the desired time were the most important omission in this study, since this area may be the number one customer service issue in paratransit. It is the subject of litigation across the country (SEPTA being the most noted example) and extensive scrutiny from the FTA Office of Civil Rights and FTA Chief Counsel.

Another interesting element is that conducting a survey on paratransit often creates the fear among users that service will be cut or eliminated. This tends to provide answers that are more favorable. "If we say it is bad, they will eliminate the service and I really depend on it." This is a fairly prevalent mindset among some respondents. These sentiments tend to skew the quality level higher than it may actually be.

Wallace, Richard R.

"Users' Manual for Assessing Service-Delivery Systems for Rural Passenger Transportation"
TCRP Report 6
Transportation Research Board, National Academy Press, Washington, D.C., 1995
http://nationalacademies.org/trb/publications/tcrp/tcrp_rpt_06-a.pdf

Context: The report is designed to meet the needs of rural transit issues in two ways. First, the study allows for the design and implementation of rural transit systems where none currently exist. Second, it allows existing operators to restructure and improve rural transit systems where they do exist.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☒ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: Case studies of five rural service providers

Transit Modes Considered: Rural demand-response (general public and specialized)

Service Contracting Addressed? Yes

Performance Measures Identified:

- *Service offered/utilization:* Ridership, service hours, vehicles in service
- *Economics/productivity:* Cost per passenger, passengers per revenue hour/mile, cost per service hour/mile

Summary: TCRP Report 6 tries to provide a guidebook to two audiences. First, it is designed to assist in the development of rural transit systems where none currently exist by looking at service options, operational exigencies, and case studies including best practices. The report attempts to provide benchmark standards for effective and efficient service. Second, it allows existing operators to restructure and improve rural public resources to maximize effectiveness and efficiency.

The report notes five unique aspects of rural transportation that need to be considered in assessing effectiveness and efficiency:

- Origins and destinations are dispersed
- Low density in demand
- Different characteristics of transportation disadvantaged
- Nature of trips demanded
- Lifestyles and characteristics of small urban residents

A sixth unique characteristic is that demand-responsive service predominates in rural transit, with 66 percent of the rural agencies surveyed providing no fixed-route service and either exclusively demand-responsive service or a mix of demand-responsive and flexible routing or subscription routing service.

Several agencies are cited in case studies illustrating their approach, what works, how they adjust to changing circumstances, why it works, and what does not work. One of the keys to the study is to show there is a wide range of approaches, and it is important that the transit service be designed and implemented to meet the communities' needs.

Wallace focuses upon four key performance measures. For three of these, he provides clear definitions. First, he considers cost efficiency, which is cost per vehicle hour or mile. Second is service effectiveness, defined by passengers per service hour or mile. Third is cost effectiveness, defined by cost per passenger. Service quality is the fourth measure; it is not clearly defined.

Traditional cost and efficiency measures are clearly seen as key, with quality measures seen as secondary. Williams contends that, if your transit agency's cost and efficiency numbers are good, implicitly you are meeting the community's needs. Given that the service is usually provided where alternatives are limited or non-existent, that does not say that the system is good.

Comments: One of the case studies (Alma, Michigan) indicates that, when demand rose to exceed budgetary levels, the agency chose to cut hours of service, eliminate weekend service, and raise fares to reduce demand. Its service was apparently seen as an effective, high quality service, and Alma had to reduce the quality from a customer service standpoint to meet its budgetary restrictions. That potential problem exists in rural transit systems and ADA and non-ADA urban demand-responsive systems.

Wallace, Richard R., et al.

"Who Noticed, Who Cares? Passenger Reactions to Transit Safety Measures"
Transportation Research Record 1666
Transportation Research Board, Washington, D.C., 1999

Context: Survey of passenger perceptions of transit system safety improvements

Applicability to G-6 Project:

- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology
- ☒ Other: Discussion of safety and security issues

Transit Systems Evaluated: Ann Arbor, MI

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? No

Performance Measures Identified:

- *Comfort & convenience:* Safety and security

Summary: In this paper, the authors identify station and service characteristics that riders are concerned about when evaluating transit service safety. The conclusions of this study are:

- Safety measures must be visible in order to influence perceptions of safety.
- Riding after dark and waiting at a specific Ann Arbor transit center were perceived as the least safe rider activities, so safety improvements targeted to these activities were more noticeable to riders.
- A passenger's feeling of safety is more influenced by passenger characteristics than service characteristics.

Comments: The third conclusion points out how difficult it is to measure safety and security and incorporate such characteristics in performance measurement. The authors recommend that future research analyze actual crime data in conjunction with surveyed crime perceptions.

Widawsky, I. David

Passenger Security in the Subways: An Analysis of Crime, Fear, and Perceptions of Insecurity in the New York City Subway System & A Review of Passenger Security Measures in Other Rail Transit Systems and Their Applicability to the Subways
Permanent Citizens Advisory Committee to the Metropolitan Transportation Authority, New York City, NY, November 1989

Context: This is the first of three reports produced by the Permanent Citizens Advisory Committee (PCAC) about crime and personal security on New York MTA rail lines. The other two reports, for the Long Island Rail Road and the Metro-North Commuter Railroad, are very similar to the report for the subways and will not be written up independently.

Applicability to G-6 Project:
- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology
- ☒ Other: Discussion of crime and security issues

Transit Systems Evaluated: MTA-New York City Transit

Transit Modes Considered: Heavy rail

Service Contracting Addressed? No

Performance Measures Identified:
- *Comfort & convenience:* Personal security

Summary: This paper is about crime and how riders perceive their personal security in the New York City subway system. It contains much information about characteristics of rail transit that make riders feel unsafe and about actions that agencies can take to manage "disorder" on their rail systems. It includes surveys of rail systems worldwide and concludes with 22 recommendations for making the New York City subway more secure for its riders.

Comments: This paper contains a lot of good information about crime on rail transit, riders' perceptions of crime on rail transit, and agencies' steps to control both, but it is not relevant to TCRP G-6 except insofar as it shows the high degree to which personal security is a subjective, hard-to-quantify measure. The author provides subway crime statistics and compares them to statistics for other environments, but it is clear from this paper that crime statistics do not measure unease associated with the *possibility* of crime. This should be kept in mind when evaluating safety and security measures identified elsewhere in the TCRP G-6 research.

The companion reports on the Long Island Rail Road and the Metro-North Commuter Railroad are very similar to the New York subways report and do not add new information that is relevant to TCRP G-6.

Wilbur Smith and Associates, Inc.

Bus Services Policies and Standards
Prepared for Southeastern Michigan Transportation Authority
Detroit, Michigan, 1976

Context: This project report was intended to help the SEMTA transit system develop its goals, objectives, policy guidelines, and service standards.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☒ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: The Southeastern Michigan Transportation Authority (SEMTA)

Transit Modes Considered: Urban fixed-route bus

Service Contracting Addressed? No

Performance Measures Identified: See the summary.

Summary: This report outlines five basic goals for the system and then creates policy guidelines to fulfill each goal. The goals are broken into accessibility, service quality, environmental aspects, financial requirements, and economic considerations. After evaluating the types of transit services available in the region, the report sets a number of service standards to meet their guidelines. Examples of such standards are:

- At least 12 hours of service per day
- No more than one-quarter mile between bus stops
- No more than a 20 percent passenger transfer rate
- No more than 15-minute demand headways

The final chapter outlines the impact that these standards have on the SEMTA system and discusses guidelines for the creation of new routes to operate in accordance with the standards and the modification of old routes to meet them.

Comments: This project report is highly specific and focuses exclusively on the SEMTA system. It is a good demonstration of the real-world application of a performance measure program in the mid-1970s.

Williamson, Jennifer, and Daniel Boyle

"Refinement and Use of Service Standards at the Metropolitan Transit Development Board"
Presented at the 80th Annual Meeting of the Transportation Research Board
Transportation Research Board, Washington, D.C., January 2001

Context: Review of performance standards

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: The paper was prepared for the Metropolitan Transit Development Board (MTDB) in San Diego, CA. The agencies surveyed were PAT (Pittsburgh, PA), Tri-Met (Portland, OR), Calgary Transit, TTC (Toronto, Ontario), Houston METRO, VIA (San Antonio, TX), and Vancouver's BC Transit.

Transit Modes Considered: Urban fixed-route bus, light rail; MTDB's policy in 2000 generally applied to fixed routes

Service Contracting Addressed? No

Performance Measures Identified:

- *Economics/productivity:* Passenger boardings per revenue mile, passenger boardings per revenue hour, subsidy per boarding passenger, passenger miles per seat mile

Summary: This paper describes proposed changes to MTDB's then-current performance standards and the process of gaining Board approval for the changes. The paper includes an assessment of possible performance measures, a survey of transit agencies "with the reputation for innovation in service evaluation techniques," and discussion of relevant issues that MDTB intends to address in the future.

The service evaluation policy that was current in 2000 was developed in 1993 and was known as Policy 43. This policy was intended to "establish an annual process for evaluating service and identifying service changes to improve performance." It was based on three performance measures: passenger boardings per revenue mile, subsidy per boarding passenger, and passenger miles per seat mile. Averages and standard deviations were used to classify each route as Unsatisfactory, Marginal, Satisfactory, or Exceeding Standards. Classification occurred separately for each performance measure. Overall, the policy required "extensive data manipulation" and the resulting classifications provided little detail, so the policy was not frequently used. Studies in 1998 highlighted the need to review the existing standards.

A survey was part of the review of existing standards. The survey was intended to discover key issues in the evaluation of new service. These issues included:

- *Estimated cost* – generally unbiased, but marginal costs can be "controversial"
- *Estimated ridership* – the most subjective issue
- *Other factors* – such as demographics and trip generation
- The evaluation process – measures identified are cost, ridership, passengers per hour, passengers per mile, farebox recovery ratio, and subsidy per trip; new and existing routes are generally evaluated according to different standards
- *The evaluation time frame* – the surveyed agencies evaluate new routes by standards for existing routes after a "trial period" that ranges from six months to two years

- *Sunset provisions* – "a new route will be discontinued [at the end of its evaluation period] unless the Board of Directors or other governing body specifically votes to retain it"

The proposed changes to Policy 43 include:

- *Using a Single Route Score to Identify Poorly Performing Routes* – Scores for three performance measures were averaged; routes were classified as Unsatisfactory, Marginal, Satisfactory, or Exceeding Standards (on a sliding scale) on the basis of the averaged score.
- *Developing and Applying a Continuous Index* – The score is based on the ratio of a given route's performance to the average for all routes; a score of 1.0 indicates average performance. The Board chose the continuous index over the sliding scale.
- *Introducing Passenger Boardings per Hour* – The Board wanted to focus more on passenger boardings.
- *Separating Feeder Routes into Urban and Suburban Service Categories* – Operators were concerned that the "Feeder" category was too general.

In the new policy, service is evaluated at three levels:

- *Trip-level* – includes complaints, field reports, and operator input
- *Route-level* – "an annual Policy 43 review"
- *New service evaluation* – extends 24 months after implementation of new service

The relevant issues identified for future study are:

- *Lifeline service* – lifeline service is provided where average subsidy per passenger is less than twice the average subsidy per passenger systemwide, or where no other transit service is provided within one-half mile; the minimum level of lifeline service is 60-minute headways between 6:00 a.m. and 6:00 p.m.
- *Need for additional categories* – Local Circulator category should be studied
- *Transit-oriented developments* – Policy 43 does not give preference to transit-oriented development in the evaluation of new service

Comments: This paper focuses on differences between standards for new and existing service. It also highlights standards for different route structures (e.g., feeder service versus crosstown service) and different analysis levels (e.g., trip- and route-level). The authors emphasize that standards must be flexible.

An interesting comment of the authors is, "No transit system would automatically discontinue a poorly performing route based upon the outcome of an evaluation procedure."

Wisnewski, Edward

"Restructuring A Paratransit System: The Broward County Model"
Proceedings of the 2000 Bus and Paratransit Conference, American Public Transportation Association, Houston, Texas, 2000

Context: Descriptions of the efforts of Broward County Transit to redesign paratransit service to improve quality and control costs

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☐ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☒ Applications of technology

Transit Systems Evaluated: Broward County Transit (Ft. Lauderdale, FL)

Transit Modes Considered: Urban demand-response (specialized)

Service Contracting Addressed? Yes

Performance Measures Identified:

- *Community-based:* Focus group partnership
- *Service delivery:* Customer complaints
- *Service offered/utilization:* Customer choice concept
- *Economics/productivity:* Cost per trip

Summary: The author has managed the paratransit system in Broward County and writes of the organizational transformation that has occurred in the last several years and the outcomes it has provided. While this article does not focus heavily on performance indicators, it is significant because it uses a different approach.

Service delivery was transformed, and the new structure was an outcome of a partnership between paratransit customers, human service agencies, and the transit agency. What was thought of as quality and efficiency were not simply driven by agency perceptions. As a result, a quite innovative model of paratransit service delivery was developed in Broward County.

Broward County's paratransit faced in the early and middle 1990s rapidly increasing ridership, spiraling service costs, and deteriorating quality. Service complaints exceeded 2,000 per month. A radical redesign led to close partnership with agencies and riders. The new system that was designed provided a competitive environment among several service providers for paratransit. Riders could choose among several providers. Combined with this change, compensation to private providers was changed from an hourly to a per trip basis.

Complaints declined from 2,000 to less than 50 per month in the newly redesigned system. Broward County's program has been recognized in Florida and nationwide as a best practice model. Broward County's approach needs to be considered in developing performance measures due to its innovative approach and its emphasis on meeting customer and stakeholder concerns rather than trying to define what they are internally.

Young, J.A.

Passenger Comfort in Urban Transit Vehicles
Ontario Ministry of Transportation and Communications, 1976

Context: Research project

Applicability to G-6 Project:
- ☐ Performance-measurement program description(s)
- ☐ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: None

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified:
- *Comfort & convenience:* Passenger space, noise, and vibration levels

Summary: This paper contains tables with information, averages and recommendations for:

- Transit seat dimensions for several rail systems
- Detailed car dimensions
- Chart of ratio of door openings to car length
- Transit vehicle entry step heights
- Transit vehicle door flow rates

Recommendations on optimal door widths, aisle widths, and interior designs provide compromises between capacity and comfort. Data on car lighting, noise, and vibration level standards are possible components of quality of service.

Comment: Equating the total door width along the side of a car as a percentage of the car's length and relating this percentage to boarding and alighting flows has merit.

Other suggested standards for passenger comfort are quantified and may allow a simple quality of service criterion whereby a vehicle is classed as above or below the North American (or, in the case of this paper, the Canadian) average.

Zerrillo, Robert, Carol Keck, and Norman Schneider

"Analysis of Transit Performance Measures Used in New York State"
Transportation Research Record 797
National Academy Press, Washington, D.C., 1981

Context: This paper evaluates the effectiveness and comparability of 15 multimodal performance measures in use in New York State.

Applicability to G-6 Project:

- ☒ Performance-measurement program description(s)
- ☒ Characteristics of effective performance measures or measurement systems
- ☒ Performance measure examples
- ☐ Market research
- ☐ Performance reporting
- ☐ Applications of technology

Transit Systems Evaluated: All NYSDOT funded systems

Transit Modes Considered: All

Service Contracting Addressed? No

Performance Measures Identified:

- *Service offered/utilization:* Revenue passenger per revenue capacity hour, revenue passenger miles per capacity hour/capacity mile, revenue passengers per employee hour, revenue passenger miles per employee hour
- *Economics/productivity:* Revenue capacity hours per employee hour, revenue capacity miles per employee hour, revenue vehicle hours per vehicle, revenue vehicle miles per vehicle, operating cost per capacity mile/capacity hour, operating revenue per operating cost, operating cost per revenue passenger mile, deficit per revenue passenger mile

Summary: This paper conducted a correlation analysis of all 15 performance measures used by the New York State DOT to evaluate their degree of relatedness. It found that these 15 multimodal performance measures were not significantly correlated, indicating that operator performance in one measure did not significantly affect operator performance in another. As a result, the performance measures do, in fact, measure the aspects of transit performance that they were intended to, without being influenced by other measures. Also of note, this paper found that the performance measures were equally applicable across transit modes and service types (inner city versus suburban). The authors conclude that the 15 measures in use by the NYSDOT are useful policy tools and accurately correspond to real operating phenomena within its transit systems.

Comments: The primary point of this paper is that good performance measures should measure real world phenomena in such a way that changes in any one measure are not influenced by changes in other measures. This allows for accurate assessment of the variable being measured.

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APPENDIX B: ANNOTATED BIBLIOGRAPHY INDEXES

AUTHOR INDEX

SUBJECT INDEX

Performance Measurement Program Descriptions

Characteristics of Effective Performance Measures or Measurement Systems

Performance Measure Examples

Market Research

Performance Reporting

Applications of Technology

Service Contracting

Other