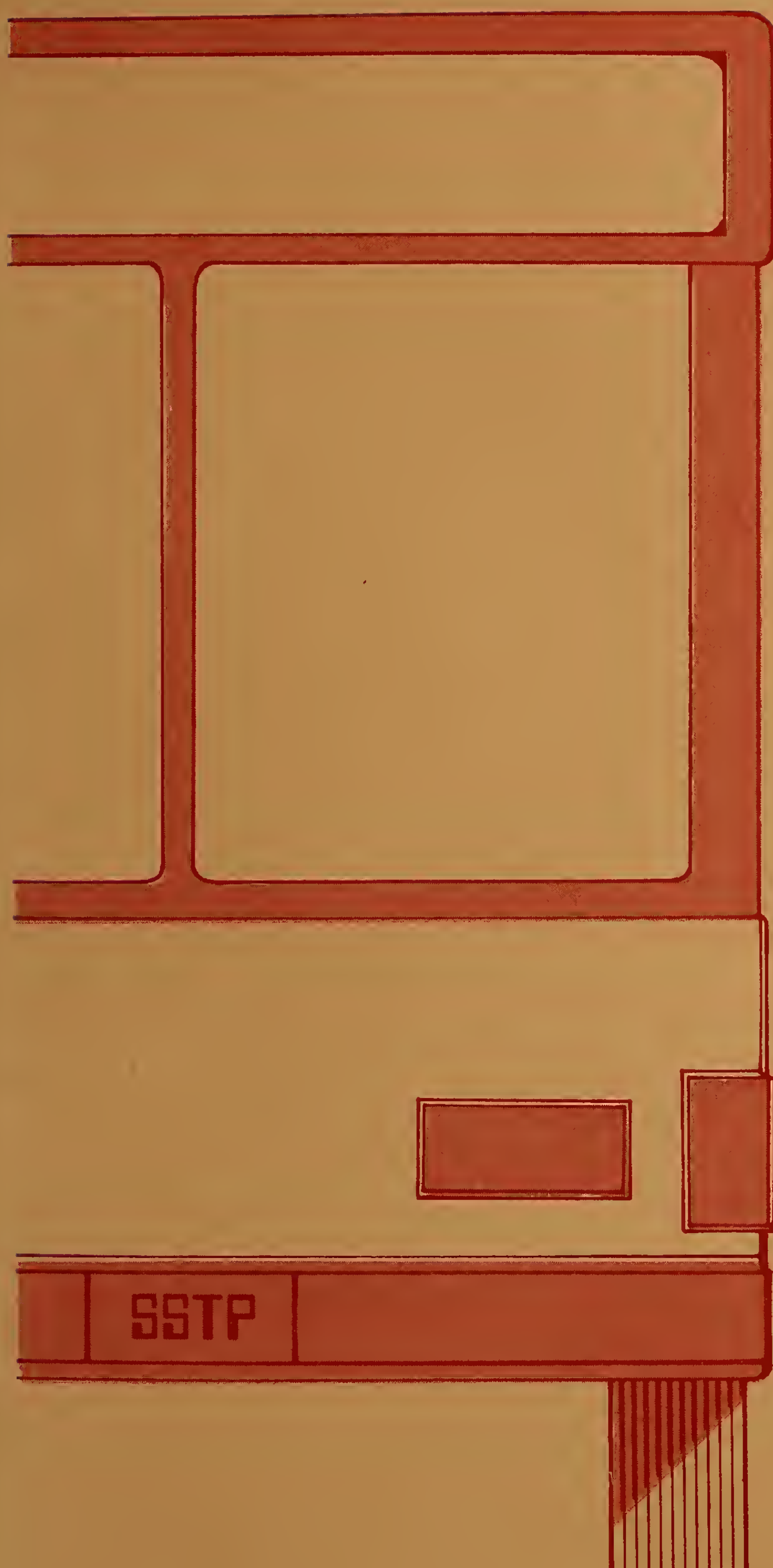

bus transit monitoring study

data requirements & collection techniques

Form DOT F 1320.1 (6-78)

DEPARTMENT OF TRANSPORTATION
URBAN MASS TRANSPORTATION ADMINISTRATION

UNITED STATES GOVERNMENT

memorandum

Subject: Bus Transit Monitoring Study Data Requirements and Collection Techniques

Date: MAR 24 1980

From: Brian McCollom *Brian McCollom*

Reply to Attn. of:

To: Distribution

The objective of the Bus Transit Monitoring Study is to develop a comprehensive statistically based data collection plan that will enable transit operators to collect passenger related data in a cost-effective manner. This first interim report presents the results of the first two tasks of the study: identifying current data collection techniques and data requirements. These two closely related tasks were conducted in parallel through three major activities: 1) a literature review; 2) a review of material collected by the Massachusetts Bay Transportation Authority (MBTA, Boston) and the Tidewater Transportation Commission (Norfolk, Virginia) in a study for UMTA focussing on service evaluation techniques; and 3) discussions with forty-one transit properties in the United States and Canada.

We believe that this report will be valuable to operators in their efforts to improve their data collection systems.

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Report No. UMTA IT-09-9008-79-1

BUS TRANSIT MONITORING STUDY

Interim Report 1

DATA REQUIREMENTS

&

COLLECTION TECHNIQUES

prepared for

Urban Mass Transportation Administration

by

Multisystems, Inc.

and

ATE Management and Service Co., Inc.

April 1979

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16. Abstract

The objective of the Bus Transit Monitoring Study is to develop a comprehensive, statistically based data collection plan that will enable transit operators to collect passenger related data in a cost-effective manner. This first interim report presents the results of the first two tasks of the study: identifying current data collection techniques and data requirements. These two closely related tasks were conducted in parallel through three major activities: (1) a literature review; (2) a review of material collected by the Massachusetts Bay Transportation Authority (MBTA, Boston) and the Tidewater Transportation Commission (Norfolk, Virginia) in a study for UMTA focussing on service evaluation techniques; and (3) discussions with forty-one transit properties in the United States and Canada.

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FORWARD

Many transit operators have adopted sets of service performance measures and standards and have developed plans to use them in a systematic evaluation. In many cases, however, transit operators have not been able to implement the measures and standards because they have had difficulty in developing a cost-effective system to collect the needed information. To assist these operators, UMTA's Office of Planning Assistance, through its Special Studies Program, has initiated a study in data collection. The purpose of this study is to develop a comprehensive statistically based data collection manual that will enable transit operators to collect passenger-related data in a cost-effective manner.

This document represents the first interim report from the study. It summarizes an examination of data needs and current collection techniques used by transit operators. We believe this "State-of-the-Art" review will be of value to transit operators in their efforts to improve their data collection systems.

Additional copies of this report are available from the National Technical Information Service (NTIS), Springfield, Virginia 22161. Please reference UMTA-IT-09-9008-79-1 on the request.

CH Graves

Charles H. Graves, Director
Office of Planning Assistance (UPM-10)
Urban Mass Transportation Administration
U.S. Department of Transportation
Washington, D.C. 20590

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Chapter 1

INTRODUCTION

1.1 Objectives of the Project

In recent years, an interest in revitalizing public transportation has led to an increased awareness of the need to utilize existing resources more efficiently. This implies that transit properties must carefully evaluate (or re-evaluate) all services, both current and planned. As a result, the collection of passenger-related transit operations data has received much more attention. Research into the utilization of this data has considerably advanced the state-of-the-art of transit evaluation and, simultaneously, generated considerable controversy regarding its proper role. Some properties, faced with an increasing need to provide the most effective service, have adopted sets of performance measures and standards, and developed plans for using them in a systematic service evaluation.

In many cases, however, this has not been accompanied by the development of a comprehensive data collection plan to allow standards to be effectively implemented. Such a plan must answer the question: How can passenger-related performance data be collected in the most cost-effective manner?

The last extensive look at transit data collection practices was conducted by the American Transit Association (ATA) thirty years ago. In the years 1946 through 1949, the ATA published several in-depth studies regarding techniques for traffic checking and schedule preparations. In 1946, the Manual of Traffic and Transit Studies, which described alternative procedures for the collection of passenger load and running time information, was released. In 1947, the ATA commenced a four-part research study into techniques for traffic checking and schedules development. The first part consisted of an in-depth description of "sample" procedures based on the

New Orleans Public Service Inc. In the second part, a survey of scheduling practices was carried out with responses received and reported from over seventy transit systems in North America. The third part of the research study was a symposium on industry practices designed to provide commentary on the results of the first two study parts. In the last part of the study, selected areas for improved techniques were investigated.

For nearly three decades, these ATA reports have constituted the only comprehensive reference source regarding service monitoring data collection and analysis techniques, and most transit properties continue to rely on the techniques described in the manual. For the most part, these techniques are extremely effective. However, they do not take into account many of the changes that have occured within the transit industry in the ensuing years (e.g., the introduction of multiple fare structures and the importance being placed on service to the elderly). More importantly, perhaps, is the fact that the ATA manual did not explore issues involved in determining the amount of data to be collected and the frequency with which data should be collected. Indeed, different properties have very different practices with respect to sample size and frequency, and it is conceivable that some collect too little data, while others collect too much. Finally, it should be noted that a few transit properties have begun to experiment with new data collection techniques, sometimes involving new technologies. Unfortunately, little of this has been documented and thus the dissemination of information has been somewhat limited.

The major objective of this study is to develop a comprehensive, statistically based data collection plan that will enable transit properties to collect the passenger-related operations data they need in a cost-effective manner. In addition, the study will briefly address the related issue of data processing, since a critical problem for some transit properties is the lack of sufficient resources to effectively use the data they already collect. Thus, the study effort will explore ways of minimizing data processing requirements by limiting data collected to those items definitely needed, identifying sampling techniques which may avoid the need for collecting a 100% sample, and exploring cost-effective data processing techniques.

In conducting this study, a panel of experts in the field of transit operations is being asked to review all findings and assist in planning the general direction of the whole effort. The panel consists primarily of managers and planners of both small and large transit properties. In addition, it includes a representative of the American Public Transit Association (APTA) and a statistical expert experienced in transit operations.

Once the data collection plan is developed, it will be tested in Chicago to determine the costs and the ability of the procedure to accurately obtain the desired data. In addition, the Chicago "trial" will provide important insights into any problems associated with implementing each of the proposed data collection techniques.

The output of this effort will be a manual that, in effect, expands upon and updates the thirty-year old ATA document. Essentially, it will describe the data collection plan to transit operators. If the study is to prove effective, this manual is the key. It must be written so that it can and will be used by transit operators throughout the country. The manual will provide "cookbook" instructions for tailoring the plan to individual properties. In addition, it will briefly address the processing of data. Finally, it will contain instructions for estimating the costs (in staff and staff hours) of both data collection and processing.

To summarize, the purpose of this project is to design and test a comprehensive data collection system, primarily involving passenger-related transit operations data. A manual will be produced to assist individual transit properties in developing and implementing their own data collection plans in an efficient and cost-effective manner.

1.2 Interim Technical Report #1

This report presents the results of the first two tasks of the study: identifying current data collection techniques and data requirements. These tasks form the background required to develop a comprehensive data collection/monitoring system.

These two closely related tasks were conducted in parallel through three major activities:

1. a literature review;
2. a review of material collected by the Massachusetts Bay Transportation Authority (MBTA, Boston) and the Tidewater Transportation Commission (Norfolk, Virginia) in a study for UMTA focussing on service evaluation techniques; and
3. discussions with forty-one transit properties in the United States and Canada.

The literature review covered data collection techniques, performance measures currently in use or being considered, data requirements for short-range planning and scheduling, and transit evaluation methodologies. Materials were selected from government and transit industry reports and academic papers.

The analysis of material gathered in the MBTA/Tidewater survey was an important aspect of the literature review. While review of their work provided little insight into issues surrounding the collection of data, it was extremely useful in identifying those data in which transit properties are currently most interested.

Discussions with transit properties served to supplement the literature search by providing information on existing service monitoring (data collection) techniques, requirements, and constraints. The properties interviewed were selected to obtain a sample representative in both size and location.

The combination of these three activities provided a sound framework for investigating the need for a comprehensive data collection plan and determining the types of information which must be included in the documentation of such a plan. The remainder of this interim report discusses all findings to date. Chapter 2 discusses data requirements and relates them to performance measures. Chapter 3 describes data collection techniques, emphasizing information obtained in the discussions with transit properties. Chapter 4 integrates the results of both tasks and identifies a number of important data collection issues which must be addressed in subsequent tasks. Appendices include a list of properties contacted, the discussion guideline questions, and a list of the documents examined in the literature review.

Chapter 2

DATA REQUIREMENTS

2.1 The Need for Data

Management of bus transit systems forty to fifty years ago in most parts of the country was more simple, in some ways, than it is today. To a large extent, routing decisions were based on profitability. Changes were fairly easy to implement and, if they did not work, it was often possible to change things back with little difficulty. The huge captive market for transit made it possible to operate with little in the way of marketing, while increasing urban densities increased the efficiency of fixed route buses. As a result, the systematic analysis of passenger-related transit operations data was not of major concern.

A variety of factors have changed this situation over the past thirty years. Increased automobile ownership and changing urban development patterns contributed to the erosion of transit ridership over a long period of time. Public, rather then private ownership of transit systems has become the rule. Since urban transit systems have virtually ceased to be profit-making operations, it is no longer appropriate to make operating decisions solely on the basis of dollars and cents. Indeed, local objectives for transit service may be quite diverse, ranging from providing mobility to the elderly, to reducing automobile utilization and energy consumption. Management decisions must now be sensitive to a whole range of local objectives.

The resources available for urban transportation increased with public ownership and facilitated a reversal of the trend of ridership decreases. However, given the emerging fiscal conservatism and growing scrutiny of public expenditure, it is becoming increasingly important to provide the most cost-effective service. In some areas, the resources available to

support transit operations are firmly fixed; the costs of providing new or expanded service must be offset by reductions in cost elsewhere in the system; i.e., by making service cuts. It is therefore necessary to be able to confidently predict both the net cost of changing or adding service and the cost which can be avoided by cutting service.

At the same time, increasing emphasis is being placed on marketing public transportation as a means of attracting new riders. As part of the marketing process, it is important to understand who is using the system (and thus who is not) and how it is being used. In addition, since the best form of marketing is the provision of high quality service, the monitoring of system performance may be considered part of the overall marketing effort.

Given these factors, it is increasingly important for transit managers to have up-to-date information on passenger-related operating performance. Some properties, including the MBTA in Boston, Metro in Seattle, and the San Diego Transit Corporation, have responded to the situation by developing systematic route evaluation programs. Such programs are typically based on local objectives and the use of performance measures and service standards. They require systematic data collection to give management the kind of information needed on a regular basis to avoid managing by reaction only.

On-going evaluation may allow management to pinpoint potential problems before they become critical. By continuously monitoring passenger-related performance on all routes, it is possible to quickly identify areas with potential for improvement, regardless of whether they are problems or potential problems. Such a system can also be an effective way of both assuring the public of accountability and meeting all external reporting requirements.

Unfortunately, the development of a system evaluation plan does not always ensure the implementation of that plan. The critical problem is typically that of perception: it is easy to assume that implementation will be extremely costly, and thus not even worth considering. However, by basing the plan on statistically sound sampling techniques, it should be possible to minimize data collection efforts while still obtaining all data necessary for good planning and scheduling. In so doing, the plan will allow properties to most effectively use existing resources.

The remainder of this chapter describes the data needs identified by transit properties (in their internal literature, response to the MBTA/Tidewater survey, and/or telephone discussions) which must be included in the data collectiohn plan.

2.2 Transit Performance Measures and Data Requirements

Upon completing the literature review and discussions with transit properties, it became clear that an effective way to determine data requirements is to first identify performance measures and then specify the associated data. This approach immediately connects the data collected to its intended usage.

The concept of performance measures has generated a considerable amount of research and debate in recent years. The use of performance measures has been clearly identified as an important management tool for both short-range planning and scheduling. Performance measures can be used to compare different elements of a system, monitor trends, and measure system efficiency. Many transit properties in the U.S. and Canada have already begun to adopt sets of such measures.

In focussing on performance measures, it is not meant to be implied that operations data are needed only to develop such measures for performance evaluation. On the contrary, performance measures, per se, are of no use unless they play a role in overall planning and operations. In addition, the majority of data collected by a property may be used for a variety of purposes, whether or not a set of formal measures exists. Data, such as passenger loads, revenue, and transfer rates, are needed for activities such as scheduling, route planning, and financial reporting, to name just a few. The collection of a comprehensive data set should help ensure that these activities are carried out as effectively as possible.

In this study, the emphasis is placed on performance measures requiring collection of passenger-related operations data. No attempt is made to examine measures of efficiency (e.g., revenue/platform bus hours) or measures relating to system design (e.g., bus stop spacing). The passenger-related measures identified in the review of literature (which covered a fair amount of unpublished transit property reports), the MBTA/Tidewater survey, and discussions with transit operators are aggregated into logical groups which are briefly described in the discussion that follows.[1] The data needed to develop these measures are identified in tables following the discussion of each group.

The four groups are: service measures; effectiveness measures; economic measures; and socioeconomic characteristics. Following the discussion of these measures and the associated data requirements, a list is presented of all the most basic data items, from which all other items can be obtained.

Service Measures

"Service measures" can be used to evaluate the quality of service experienced by transit passengers. Eleven such measures were identified:

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[1]It should be pointed out that not all measures are used with equal frequencies and no single property uses all of them. In fact, some reported measures are not being used at all at this time.

1. load factor
2. schedule adherence
3. standing time
4. transfer percentage
5. transfer time
6. travel speed
7. travel time
8. wait time
9. average fare
10. cancelled runs
11. accident rate

The first two measures listed, load factor and schedule adherence, are the measures most frequently used by the transit industry. Load factor typically refers to the ratio of passengers to seats on a bus at a specific time and/or location along a route. Schedule adherence is the extent to which buses arrive on time and/or at scheduled frequencies. These measures are of particular importance because they are used to adjust vehicle schedules.

Standing time refers to the amount of time any one passenger spends standing on the bus. It will depend both on the load factor and the passenger turnover rate. Some properties suggest the use of this measure in conjunction with load factor as a basis for determining whether headway adjustments are needed.

The transfer percentage (between route pairs) is a measure used in making routing decisions (e.g., the through routing of two routes). While transfer data might be relatively easy to obtain in systems which issue transfers, it is a much more difficult problem for systems which do not do so.

Some properties include transfer time, the delay experienced by passengers transferring between two routes, as a service measure. To a large extent, transfer time is determined by the system schedule (as well as schedule adherence). Thus, there may be no need to measure it directly. The same is true for (average) wait time, the time spent by an average passenger waiting at a bus stop for a (first) vehicle. Both of these measures could be used to ascertain the quality of service being provided to passengers. In that way, they may indirectly influence system design.

Travel speed generally refers to vehicular speed: average bus miles/bus hour for a specific route or route segment. On the other hand, point-to-point travel times are typically measured for both vehicles and passengers. Passenger travel times are the same as vehicle travel times only if no transfers are involved. Average unlinked trip time is a measure required by Section 15.[1] Changes in vehicle and passenger travel times are often considered in estimating the quality of service and costs and benefits of a proposed service alteration. Finally, both travel time and speed are sometimes presented as ratios of transit time or speed to auto time or speed, thus providing a means of comparing the alternative modes.

The average fare is both an economic measure (revenue per passenger) and a service measure (passenger expenditure per trip). This figure is often used to convert revenue data to ridership estimates.

The number of cancelled runs influences the load factor, schedule adherence, standing time, and travel time and speed. The necessary data is obtained from dispatcher, road call, or supervisor reports.

The last service measure listed is the accident rate. In some cases, it is recorded as passenger and traffic accidents per vehicle-mile. In other cases, only traffic accidents are explicitly considered in the service measure. As with cancelled runs, the necessary data is typically obtained from supervisors' reports.

The service measures and data needed to develop each measure area listed in Table 2.1.

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[1]A definition of unlinked trips is presented on page 16 in the section "Effectiveness Measures."

Table 2.1

SERVICE MEASURE DATA REQUIREMENTS

Measure	Data
1. Load factor	Number of passengers on bus - by tod, dow, rt, loc, dir* Bus seating capacity
2. Schedule adherence	Bus arrival time - by tod, dow, rt, loc, dir, trp Scheduled arrival time
3. Passenger standing time	Number of minutes each passenger stands - by tod, dow, rt seg, dir
4. Transfer percentage	Number of passengers transferring between route pairs Total passenger trips on each route (2.2.4)** - by tod, wd/we, loc, dir - by transferring passenger characteristics
5. Transfer time	Arrival time of bus originating transfer Arrival time of bus terminating transfer Transfer percentage (2.1.4) - by tod, wd/we, rt pair, loc, dir Walk time between originating and terminating bus stops

*Initials Key:

tod	- time of day	dir	- direction
dow	- day of week	trp	- bus trip
rt	- route	rt seg	- route segment
loc	- location	wd/we	- weekday/weekend

**Refers to Measure 4 in Table 2.2.

Table 2.1

SERVICE MEASURE DATA REQUIREMENTS

(continued)

Measure	Data
6. Wait time	Bus arrival time Boarding passenger arrival time - by tod, wd/we, rt, stop, dir
7. Bus travel speed	Bus arrival time - by tod, wd/we, rt, dir - by stop pairs of interest (spi) Number of bus route miles between stop pairs of interest
8. Bus travel time	Bus arrival time - by tod, wd/we, rt, spi, dir
9. Ratio of bus travel time to auto travel time	Bus travel time (2.18) Auto travel time - by tod, wd/we, spi, dir
10. Passenger travel time	Bus travel time (2.18) Wait time (2.1.6) Transfer time (if applicable) (2.1.5)
11. Ratio of passenger travel time to auto travel time	Passenger travel time (2.1.10) Auto travel time - by dow, wd/we, dir - by location pairs
12. Average fare	Total passenger revenue Total passenger boardings - by tod, wd/we, rt

Table 2.1

SERVICE MEASURE DATA REQUIREMENTS

(continued)

Measure	Data
13. Percentage of cancelled bus trips	Number of scheduled bus trips Number of cancelled bus trips - by tod, wd/we, rt, rt seg, dir
14. Vehicle accident rate	Number of bus accidents Number of bus-miles - by rt, operator
15. Passenger accident rate	Number of passenger accidents Number of passenger boardings Number of bus-miles - by rt, operator

Effectiveness Measures

"Effectiveness measures" are used to evaluate the extent to which potential service capacity is utilized. Many of the measures are in the form of passengers-trips per unit of service supplied (such as bus-miles or bus-hours) and indicate how effective a transit operation is at serving a high number of people with a relatively low expenditure of labor and equipment. Eighteen measures were identified.

1. annual passenger trips
2. passenger trips per capita
3. change in ridership
4. passenger-trips by route
5. passenger-miles
6. passenger-trips/bus-mile
7. passenger-trips/route mile
8. passenger-trips/route segment
9. passenger-trips/bus-hour
10. passenger-hours/bus-hour
11. passenger-miles/bus-hour
12. passenger-miles/bus-mile
13. passengers/bus-trip
14. passengers/bus
15. boardings and alightings by stop
16. average occupancy
17. average passenger trip length
18. passenger turnover rate

The basic measure of effectiveness is ridership, or passenger-trips. The term passenger-trip is used here to avoid confusion over what is meant by a passenger and what is meant by a trip. A passenger is an individual riding on the bus system. A passenger-trip occurs each time an individual boards a bus. Thus, in any given day, a person may make many trips, but would still be counted as only one passenger.

An additional distinction must be made between linked and unlinked passenger-trips. A linked passenger-trip includes all buses used to travel between a passenger's origin and destination. Thus, if a passenger must transfer and ride on two vehicles, only one linked trip is counted. However, two unlinked trips have been made since an unlinked trip occurs every time a passenger rides a bus. Both measures are important and both are used.

Finally, some properties report all passenger-trips, while others only report revenue passenger-trips (which exclude free fare passengers). For all other measures which build upon passenger trips, it will be assumed that all possible permutations are measured.

Passenger-trips per capita is an interesting measure which provides an indication of overall use of the service in the community. Change in ridership (passenger-trips) is a measure used to indicate trends over a period of time. Passenger-trips by route simply involves disaggregation on a route specific basis.

Passenger-miles is one of the measures required under Section 15. Some properties have indicated that they view passenger-miles as a much more meaningful indicator of utilization of the system than the passenger-trips measure. Interestingly, London Transport views the maximization of passenger-miles as their prime service objective.

The next nine measures listed are often referred to as "productivity" measures (not to be confused with the more conventional use of the term "productivity" in relation to labor output). They measure passenger-trips, hours, and miles (output) per unit of service resource (bus-mile, bus-hour, route-mile, route segment, and bus trip (defined as a one-way bus trip between terminals on a given route)). These measures are particularly useful in identifying routes whose performance is significantly above or below the average.

<u>Boardings and alightings by stop</u> is a very important measure for two reasons. First, it is extremely useful for route planninng (e.g., analyzing the potential benefits of implementing turnbacks or other route changes, identifying stops which should have shelters). Second, it is an important "building block" for calculating many of the other performance measures.

The <u>average occupancy</u> measure is similar to the load factor level of service measure; it simply views the same figures as capacity utilization, rather than comfort to the user.

<u>Passenger-trip length</u> (average) and <u>average passenger turnover rate</u> also relate to load factor and place effectiveness measures such as passengers/mile in perspective. For example, if thirty passengers board over a five-mile route segment and each rides for only half a mile, then the average occupancy is only three passengers. But if each passenger rides the full five miles, the average occupancy is thirty. Finally, average passenger-trip length information can be used to convert passenger-trip data to a passenger-mile estimate.

The data needed to develop each effectiveness measure are listed in Table 2.2.

Table 2.2

EFFECTIVENESS MEASURE DATA REQUIREMENTS

Measure	Data
1. Annual systemwide passenger trips	Annual passenber boardings - by r/nr, l/ul*
2. Annual passenger-trips per capita	Annual passenger trips (2.2.1) Service area population
3. Change in passenger-trips over time	Passenger-trips - by rt
4. Passenger-trips by route	Passenger-trips - by tod, dow
5. Passenger-miles	Passenger trips Average passenger-trip length (2.2.15)
6. Passenger-trips per bus-mile	Passenger-trips by route (2.2.4) Bus-miles - by tod, dow, rt, rt seg
7. Passenger-trips per route mile	Passenger-trips by route (2.2.4) Route miles - by rt, rt seg
8. Passenger-trips per route segment	Passenger-trips by route (2.2.4) - by rt seg
9. Passenger-trips per bus-hour	Passenger-trips by route (2.2.4) Bus-hours - by tod, dow, rt, rt seg

*Initials Key: r/nr - revenue/non-revenue; l/ul - linked/unlinked; rt - route; tod - time of day; dow - day of week; rt seg - route segment

Table 2.2

EFFECTIVENESS MEASURE DATA REQUIREMENTS

(continued)

Measure	Data
10. Passenger-trips per bus-trip	Passenger-trips by route (2.2.4) Bus-trips - by dow, rt, time period
11. Annual passenger-trips per bus	Annual passenger-trips (2.2.1) Active buses in fleet
12. Passenger-miles per bus-mile	Passenger-miles (2.2.5) Bus-miles - by tod, dow, rt, rt seg
13. Passenger-miles per bus-hour	Passenger-miles (2.2.5) Bus-hours - by tod, dow, rt, rt seg
14. Occupancy	Passengers on bus - by tod, dow, rt, direction - by location (loc) Boardings and alightings by stop (2.2.16)
15. Average passenger-trip length	Boardings and alightings by stop (2.2.16) - by tod, dow, rt, rt seg Bus route miles between stops
16. Boardings and alighting by stop	Passengers boarding Passengers alighting - by r/nr, tod, dow, rt, loc - by transfer/non-transfer

Economic Measures

"Economic measures" are typically used to evaluate the cost (net and total) of providing transit service along a route, for a specific time period, and/or systemwide. A total of twenty-two economic measures have been identified.

1. revenue-cost ratio
2. subsidy-cost ratio
3. cost by route
4. revenue by route
5. subsidy by route
6. cost/mile
7. revenue/mile
8. subsidy/mile
9. cost/hour
10. revenue/hour
11. subsidy/hour
12. cost/passenger-trip
13. revenue/passenger-trip
14. subsidy/passenger-trip
15. cost/passenger-mile
16. revenue/passenger-mile
17. subsidy/passenger-mile
18. cost/bus
19. revenue/bus
20. subsidy/bus
21. annual deficit/individual passenger
22. annual deficit/capita

The first five measures are fairly aggregate economic performance indicators. The revenue-cost ratio, which may be calculated on a system-wide or route specific basis, is the inverse of the operating ratio measure commonly used when public transit was profitable. The subsidy-cost ratio is simply one minus the revenue-cost ratio. Cost, revenue and subsidy by route are all measures of route performance. While it is typically straightforward to develop these cost measures on a systemwide basis, route specific performance is much harder to estimate.

Many properties have developed cost allocation models to estimate costs by route. These models typically rely on estimates of unit costs (per mile, per hour, per bus) determined on a systemwide basis and then applied to individual routes. Some properties have attempted to improve the cost allocation scheme by including adjustment factors (e.g., speed) to tailor unit costs to each route. (These schemes are of only peripheral interest to this study because the prime focus in on passenger-related operations data collection; an allocation scheme is simply an accounting tool.)

Many properties use unit costs (and revenue or subsidy) per mile and per hour as a means of comparing economic performance among routes and/or as input to cost allocation formulas.

Cost, revenue, and subsidy per passenger-trip are also frequently used measures. However, some properties believe that estimating these measures on a per passenger basis is not sufficient since travel distances impact the cost of providing service. Hence, cost, revenue, and subsidy per passenger-mile may also be computed.

Cost,revenue, and subsidy per bus are measures which effectively involve frequency and amount of service (which are functions of the number of buses on a route).

Deficit per individual passenger is a measure which spreads the deficit over all individuals who use the service (i.e., actual passengers rather than passenger-trips). Deficit per capita spreads the deficit over all persons in the service area.

No table has been developed to present data needs for economic measures for two reasons: (1) the data requirements are implicit in the names of the measures and are identified in detail in Table 2.2; and (2) the data required to determine costs will depend on a property's cost allocation scheme.

Socioeconomic and Travel Pattern Characteristics

Passenger characteristics are important from a marketing perspective;[1] in addition, such data may enter into performance evaluation if service standards are adjusted for routes which serve a specific target market, such as the elderly. Seventeen measures were identified:

1. age
2. handicap
3. sex
4. job status
5. income
6. auto ownership
7. auto availability
8. home location
9. school and/or work location
10. origin/destination
11. time of day of work or school trip
12. work or school trip mode
13. non-work or school trip modes of travel
14. non-work or school trip times of travel
15. work, school, and other trip frequency
16. attitude toward level of service

The first eight measures are passenger socioeconomic characteristics. The next seven relate to passenger travel patterns. The last measure is passenger attitudes toward the level of service provided by both transit and competing travel modes.

No table is presented for these measures since, in this case, the measure and data requirements are one and the same. These data are generally collected in surveys, as discussed in the following chapter.

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[1]While non-passenger characteristics, travel patterns, and attitudes area slo important for marketing purposes, the collection of relevant data is beyond the scope of this study; they are therefore not included in this study.

2.3 Data Requirements

The previous section (2.2) presented a comprehensive list of performance measures for which a transit property may wish to collect data. Analysis of these measures indicates that most of them can be calculated from just a few data items. This "boiled down" list of data requirements is presented in Table 2.3. The techniques which can be used to collect these data are discussed in the following chapter. (The last group requires essentially no collection effort since the data should be available from transit records.)

Having identified these "essential" data items, it is necessary to determine the amount of data which must be collected. They key issue in addressing this problem is the intended uses of the data. The usage helps determine the level of accuracy required, which in turn helps to specify how much data must be collected.[1] For example, the scheduling function must have fairly accurate data since there may be a high penalty (e.g., crowded buses, lack of reliability, ridership decrease) associated with making a wrong decision.

The term "accuracy" can be viewed as having two components. Data may be accurate in terms of the confidence with which conclusions are drawn or in terms of the precision with which conclusions may be stated. For example, a property might say: "We want to be 95% certain (confidence level) that (our) estimate of peak load or running time is within $\pm$ 5% (tolerance limit) of the true value." Discussions with transit properties[2] indicated that few operators consider this twofold nature of accuracy. Most of the properties contacted simply felt that scheduling data needed to be "95% accurate." Unfortunately, this is not sufficient to determine how much data to collect.

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[1]In addition, it is necessary to estimate the variability of each data item before sample size can be determined.

[2]See Section 1.2 for description of discussions.

Table 2.3

SUMMARY OF DATA REQUIREMENTS

<u>Data to be Recorded by Stop (or at selected stops)</u>
Number of passengers boarding Number of passengers alighting Number of passengers on bus Bus arrival time Revenue collected
<u>Data to be Collected by Route or Systemwide</u>
Number of fares paid by fare category Distribution of passholder trips per month Number of passholders Transfer rate between routes Number of transfers per passenger Passenger socioeconomic characteristics Passenger travel patterns Passenger attitudes toward and perceptions of transit and competing mode levels-of-service
<u>Data for Which No Collection is Required (i.e., from Transit Records)</u>
Route-miles between stops Bus-miles by route Bus-hours by route Buses by route Costs by route Bus trips scheduled by route Bus trips cancelled by route Bus and passenger accidents Bus seating capacities Scheduled arrival times

The following examples illustrate how a property might approach the question of accuracy required (and thus of the quantity of data required).

- Route planning may require relatively accurate data since performance measures can be used to make route design decisions. However, in most cases, such decisions would not be based on a single data item, but would involve some further examination. Thus, these data might only need to be determined with 90% confidence and a fairly high tolerance, perhaps ±20%.

- Data needed for Section 15 must follow UMTA guidelines, which requires 95% confidence and a tolerance limit of ±10% of the true value. Other data items needed for reporting purposes might have similar accuracy requirements.

- Finally, most marketing data are used to get a general view of the system, and, as such, are not used directly for decision-making. Thus, these data can be relatively inaccurate, perhaps in the range of 90%, ±25%.

The accuracy levels noted above are merely intended as suggestions: the final manual will provide a transit operator with the opportunity to select desired accuracy levels. The manual will also include a discussion of the implications of different confidence intervals and tolerance limits.

It should be noted that there are often trade-offs between costs and accuracy. Sample size is one area where this appears, since greater samples typically result in greater accuracy but also cost more to obtain. The type of data collection may also play a role. For example, operators may be less expensive to use than checkers for counting passengers. However, as will be addressed in the next chapter, operator counts are typically felt to be less reliabile (and hence less accurate) than checker counts. Transit operators faced with limited resources may simply have to accept lower accuracy for their data. Frequently, obtaining less accurate data would be more acceptable than collecting fewer types of data, given data collection resources.

Chapter 3

PRESENT SERVICE MONITORING TECHNIQUES

3.1 Discussions With Transit Properties: Methodology

In mid-January 1979, telephone interviews were held with representatives of forty-one (41) transit systems in the United States and Canada. A comprehensive discussion guide (displayed in Appendix B) was prepared for use by the interviewers in obtaining information on existing service monitoring and data collection techniques and requirements at each system. The sample was intended to be fairly representative in terms of size and location; a breakdown by geographic location and size of the systems contacted is presented in Table 3.1. The systems contacted are listed in Appendix A.

The telephone interview approach proved to be reasonably effective for gathering information for this study. Discussions lasted between twenty minutes and over one hour; in some cases, more than one individual was contacted to obtain necessary information, particularly at the larger systems. In assessing the quality and completeness of the interview results, it should be noted that some respondents probably answered with "how it should be" rather than "how it is." However, this should not invalidate the basic findings presented in this report.

The remainder of this chapter is divided into three sections. The first describes four general findings which will be useful in guiding future study. These have been developed from analysis of interview data and results. The next presents detailed findings pertaining to the use of specific data collection techniques. Finally, the chapter concludes with a discussion of data collection costs, as perceived by transit properties.

Table 3.1

DISTRIBUTION OF STUDY SYSTEMS BY LOCATION AND SIZE GROUP

	Fewer than 100	100 to 249	250 to 399	400 to 749	750 and Over	All Systems
West	1	2	1	3	1	8
Southwest	1	2	2	1	-	6
Midwest	3	1	2	3*	2	11
Southeast	2	3	-	2	-	7
Northeast	1	2	1	1*	4*	9
TOTAL	8	10	6	10	7	41

*Includes one Canadian system.

3.2 Key Findings Concerning Existing Data Collection Programs

3.2.1 Considerable diversity exists in the data collection techniques currently employed.

The 1947 ATA report, A Sample Procedure for Traffic Checking and Schedule Preparation, refers to the "rugged individualism characteristic of the transit industry" in cautioning that the procedures being presented are intended as a sample for generating industry comments and discussion only, and not as being "the best" or a standard. In the following 1949 report presenting discussions of the sample procedure by industry scheduling experts, one such expert wrote that:[1]

> Most of the procedures used by the sample company in gathering and summarizing information are quite similar to our own; however, the sample company seems to use a far more comprehensive system. Now the question arises as to whether this elaborate, all-inclusive system is necessary, in order to accomplish the job of building the most efficient schedule possible. We are inclined to believe that it is neither necessary nor desirable to spend quite so much time in gathering and charting these checks.

These statements of thirty years ago could be equally applied to today's service monitoring and data collection programs. In fact, it may be that today's programs have added diversity due to the need to collect additional and more detailed information.

An examination of the techniques used for passenger load and running time data collection at the forty-one study systems serves to illustrate the high degree of individuality characteristic of data collection programs. Some of the diversity may be reasonably explained. As shown in Table 3.2, systems operating over 750 buses make greater use of point checks while systems operating fewer than 100 buses depend more on operators

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[1]George Plummer, Dallas Railway and Terminal Company, quoted in "Second Report: An Industry Symposium on Passenger Load Data," in Traffic Checking and Schedule Preparation, ATA, September 1949.

Table 3.2

SUMMARY OF PASSENGER LOAD AND RUNNING TIME DATA COLLECTION PROGRAMS

Number Peak Buses	Number of Study Systems	Point Checks Only	Riding Checks Only	Operator Checks Only*	Point and Riding Checks	Point and Operator Checks*	Riding and Operator Checks*	Point Riding, and Operator Checks*	Automated Data Collection	No Program
Fewer than 100	8	-	1	5	-	-	1	-	-	1
100 to 249	10	3	-	2	1	-	2	1	-	1
250 to 399	6	2	-	1	-	-	-	2	-	1
400 to 749	10	2	-	1	2	-	-	1	1	3
750 and Over	7	3	-	-	2	1	-	1	-	-
TOTAL (%)**	41(100)**	10(24)	1(2)	9(22)	5(12)	1(2)	3(7)	5(12)	1(2)	6(15)

*Includes regular and special comprehensive passenger count programs by operators only.

**Percent of total study systems in parentheses. Note that these are not weighted totals and thus cannot be interpreted as representative of all systems nationwide.

for data collection. In addition, sysems operating in low-density urban or suburban areas may have to rely on riding check data.

However, most of the diversity in data collection techniques cannot be rationalized so easily. The diversity of data collection programs appears to be rooted in a wide variety of system-specific factors, including long-established practices and procedures, data collection costs of different techniques, labor relations, management practices and reporting requirements, system financing, and local political realities, together with a substantial amount of "rugged individualism."

3.2.2 Significant differences are found in the frequencies at which various data are being collected.

There is a high degree of variation in the frequency of collection of various data types. While the use of one technique in preference to another may be explicable in a number of ways, differences in sampling strategies for data collection are considerably more problematic. For example, data collection for service performance analysis on a daily, weekly, or monthly basis may be excessive if schedules can only be adjusted quarterly or three times annually. Also, there is no noticeable relationship between the frequency of data collection and the degree to which service is changing at a system, other than to note that some systems which are basically stable are doing relatively less data collection. However, two systems currently undergoing major changes have only modest data collection programs.

3.2.3 A significant amount of the data being collected on a regular basis is not being used.

Substantial amounts of data collected using point and operator checks are not being analyzed. Typically, this is due to the time-consuming and tedious nature of the work. Data collection efforts should be eliminated if the data are not needed, and computer processing or other time-saving data analysis techniques introduced if they are.

3.2.4 There is substantial industry activity and interest in the deployment of automated data collection systems.

Recently, there has been considerable research and development related to the implementation of automated data collection systems for collecting passenger load, schedule adherence, and running time data. The development of automated systems has been moving ahead rapidly. One study property, the Ottawa-Carleton Regional Transportation Commission (OC Transpo), has an operational system while six others are in various stages of testing and development activities. Overall, about eighty percent of the systems interviewed which operate over 250 peak buses have at least an interest in automated data collection systems.

Of the seven study properties with operational systems or systems being tested, three are working with the automated vehicle monitoring (AVM) on-line approach. The Cincinnati and Toronto systems are currently operational on a test basis, and systems development work is underway for a major UMTA-sponsored demonstration project at the Southern California Rapid Transit District (SCRTD). At OC Transpo and four other authorities (including SCRTD), data collection systems with off-line data retrieval and processing are being tested or used.

3.3 Data Collection Techniques

As noted above, the service monitoring programs of transit systems are highly diverse in the amount and types of information being collected on a regular basis. However, the techniques employed are more or less standard throughout the industry and, with the exception of automated data collection systems, have not changed significantly over the years. In the remainder of this chapter, a discussion of the use of the various data collection techniques by study systems is presented. Specifically, individual sections address the following data collection techniques:

- point checks
- riding checks
- trailing checks
- farebox data collection
- use of operators for data collection (other than farebox data)
- surveys

In addition, some properties are experimenting with or using automated data collection systems.

Table 3.3 provides an overview of the types of data typically collected using each of the common techniques. The use of each technique is described below.

Table 3.3

TYPE OF DATA WHICH CAN BE COLLECTED USING COMMON INDUSTRY TECHNIQUES

Technique	Passenger Loads	Schedule Adherence	Running Times	Route Ridership	Route Revenue	Rider Characteristics*
Point Checks	X	X	X			
Riding Checks	X	X	X	X		X
Trailing Checks			X			
Farebox Readings				X	X	X
Operator Collected Data	X	X	X	X	X	X
Surveys						X
Automated Data Collection	X	X	X	X	X	

*Includes socioeconomic characteristics, travel patterns, and attitudes toward level of service.

3.3.1 Point Checks

This data collection technique involves the stationing of an individual at a bus stop to record information about each bus as it goes by. Often, stop locations are selected such that the data checker can observe several bus routes simultaneously. The information recorded usually includes the number of passengers on-board and may include the arrival time of the bus. The data which can be collected using point checks (whether or not they actually are collected) are summarized in Table 3.4.

Table 3.4

DATA AVAILABLE FROM POINT CHECKS

- Number of passengers on bus
- Bus arrival time
- Bus departure time
- Passenger arrival time
- Number of passengers transferring (if both originating and terminating bus go by point check location)

Passenger counts at the maximum load, turnback, and branch points along a line provide the basic data needed for building efficient schedules. At the same time, schedule adherence checks at these points can be used to make running time adjustments in response to changing operating conditions.

As shown in Table 3.5, none of the study systems with fewer than 100 buses use point checks, while all study systems with over 750 buses have regular point check programs. At intermediate size ranges, about one out of two study systems

Table 3.5

STUDY SYSTEMS WITH REGULAR POINT CHECK PROGRAMS BY SIZE GROUP

Number of Peak Buses	Number of Study Systems	Systems with Point Check Programs	
		Number	Percent
Fewer than 100	8	0	0%
100 to 249	10	5	50
250 to 399	6	4	67
400 to 749	10	4	40
750 and Over	7	7	100
TOTAL	41	20	49%

conduct point checks on a regular basis. However, it is instructive to examine more closely the thirteen intermediate systems which do not have a point check program.

- Four use riding checks or operator checks instead.
- Three use occasional operator and/or supervisor checks on an "as needed" basis.
- One has an automated data collection system.
- Two utilize point checks only "as needed" (but would like to expand their programs).
- Three have no point check programs but would like to. (One of these recently ended its program due to budget constraints.)

Examination of the frequency and duration of point checks made by the twenty study systems with regular programs shows that no two systems have identical programs for point checking. The frequency of checks varies from weekly to annually, days counted from one to five per check, and both peak and all day counts are taken. As shown in Table 3.6, the majority of systems check for between six and twelve days per year.

Table 3.6

NUMBER OF DAYS CHECKED PER YEAR:
POINT CHECK PROGRAMS

Number of Peak Buses	Total Systems with Point Check Programs	Number of Days Checked Per Year*			
		Fewer than 6	6 to 12	13 to 24	Over 24
100 to 749	13	2	7	1	3
750 and Over	7	1	5	1	-
TOTAL	20	3	12	2	3

*Includes both full and partial days.

Of particular interest in discussing service monitoring data collection programs with study systems was an assessment of how the data being collected is analyzed. Typically, analysis encompasses preparation of a report showing passenger load and/or on-time performance by fifteen- or thirty-minute time periods. The use of raw check sheet data as input for building or adjusting headways is common scheduling practice, but is not considered as being data analysis as intended for this review of industry service monitoring practices. With this explanation, it is noted that about one-half of the data being collected is processed only on an "as needed" basis. (See Table 3.7.)

For systems with more than 400 buses, the proportion of data being analyzed is much greater due in part to the use of computer processing techniques. Five of these larger study systems with point check programs currently employ computerized data analysis procedures. In addition, six other systems expressed interest in, or are currently undertaking, computerization of the data analysis function.

Nearly all respondents with regular point check programs expressed satisfaction with the quality of data being collected. In many cases, checking personnel had several years of

Table 3.7

POINT CHECK DATA ANALYSIS SUMMARY

Number of Peak Buses	Number of Systems with Point Check Programs	Passenger Load Analysis	Schedule Adherence Analysis	Management Reporting*	Computer Analysis
100 to 249	5	2	1	1	-
250 to 399	4	-	-	1	-
400 to 749	4	3	3	3	2
750 and Over	7	6	2	4	3
TOTAL	20	11	6	9	5

*Summarizing of data analyses for management purposes.

experience in checking and were considered to be highly reliable. At a few systems where either part-time employees are used for checking or where checking personnel were paid significantly below operator levels, data quality concerns were reported. Perhaps the single most important concern regarding data collection by point checks is the introduction of shaded windows on advanced design buses. Checkers cannot see through these windows to count the number of passengers riding and thus must board the bus or attempt to count through the front window. At this point, it is not clear how this matter can be resolved.

3.3.2 Riding Checks[1]

This data collection technique requires that a data checker board a bus and remain on board over some or all of the route being observed. Typically, the checker records the number of people getting on and off the bus at each stop. In addition, the checker may record the bus arrival time and the number of special-fare passengers boarding (e.g., senior citizens). Riding checks can provide detailed running time and schedule adherence data as well as information on rider characteristics. With checking personnel riding all or most trips operated on a line, a complete profile of passenger boarding and alighting activity may be obtained. The data which can be collected using riding checks are summarized in Table 3.8.

Table 3.8

DATA AVAILABLE FROM RIDING CHECKS

Passengers boardings by stop
Passenger alightings by stop
Bus arrival time by stop
Bus departure time by stop
Revenue collected by stop
Time each passenger stands

[1]Also known as "on/off" and "boarding/alighting" counts.

Riding checks typically require a larger number of checking personnel to carry out than do point checks because to observe all bus trips on a route using riding checks, one checker must be assigned to each bus; a point check, however, can be conducted with only one checker for each route or for a group of routes intersecting at a single point.

Of the forty-one study systems, fourteen have a regular riding check program for service monitoring, as shown in Table 3.9.[1] In addition, a number of systems conduct riding checks for "as needed" special studies to:

- develop detailed route profiles for route planning;
- develop detailed route profiles for revenue allocation;
- meet Section 15 reporting requirements; and
- obtain distribution of passengers by fare category.

As shown in Table 3.10, the frequency of systemwide checking varies from less than one time per year at one system to about four times per year at three systems. It should be noted that, in most cases, reported systemwide frequencies probably represent "targets" for checking or actual experience with larger lines only.

One-half of the study systems with regular riding check programs also have point check programs. A common procedure is to conduct annual riding checks and quarterly or monthly point checks. Alternatively, a property may utilize a combination of riding and point checks with riding checks used more frequently for small lines and lines for which point checks cannot adequately describe operations (e.g. crosstown routes, routes with no maximum load point).

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[1]In one situation, the local MPO has been using CETA personnel to obtain on/off ridership data. However, the property (which had fewer than 100 buses) did not consider the information of any value for planning and scheduling.

Table 3.9

STUDY SYSTEMS WITH REGULAR RIDING CHECK PROGRAMS

Number of Peak Buses	Number of Study Systems	Riding Check Program		Special Studies	
		Number	Percent	Section 15	Comprehensive*
Fewer than 100	8	2	25%	1	-
100 to 249	10	4	40	2	1
250 to 399	6	2	33	1	1
400 to 749	10	3	30	-	1
750 and Over	7	3	43	2	-
TOTAL	41	14	34%	6	3

*Primarily to develop route profiles; not necessarily conducted on a regular basis.

Table 3.10

CHARACTERISTICS OF REGULAR RIDING CHECK PROGRAMS

Number of Peak Buses	Systems with Riding Check Programs	Checks Per Year			Also Point Check Program	Computer Analysis	
		One	Two	3-4		Operational	Planned
Fewer than 100	2	1	-	1	-	-	-
100 to 249	4	1	2	1	2	1	2
250 to 399	2	2	-	-	-	1	1
400 to 749	3	2	1	-	2	2	1
750 and Over	3	2	-	1	3	2	-
TOTAL	14	8	3	3	7	6	4

Analysis of riding check data appears to be more thorough than was the case for much of the point check data being collected. This may in part be a reflection of the fact that riding checks are less routine than point checks. All study systems indicated that all or most riding check data are being tabulated. Six systems have computerized data analysis and reporting, while four others are planning computerization or have programs under development. Thus, ten out of twelve systems with over 100 buses have or are developing computerized ride check analysis.

A number of comments are in order concerning the adequacy of existing service monitoring data collection efforts related to riding check programs.

- Some systems conducting riding checks only to meet Section 15 reporting requirements believe that the information collected is not worth the effort expended. It was noted that in cases where riding checks are not routinely performed, the UMTA-suggested sampling approach for selecting trips to be surveyed may lead to an inefficient utilization of staff time.

- Two systems in the 100-249 size range believe that riding check costs are not justified; others are interested in expanding efforts.

- Two large operators stressed the need for a viable sampling methodology.

While these comments present no uniform opinion, each relates to the single key issue of identifying criteria for the most cost-effective frequency of riding check data collection.

3.3.3 Trailing Checks

Trailing checks involve having a checker, supervisor, and/or schedulemaker follow a bus, usually in an unmarked vehicle, to record bus arrival times and reasons for delays. It is an effective procedure for checking route running times as well as for assessing overall street operations and performance. The data which can be collected using trailing checks are summarized in Table 3.11.

Table 3.11

DATA AVAILABLE FROM TRAILING CHECKS

Bus arrival time by stop
Bus departure time by stop
Bus speed at any point along route
Factors influencing route performance

Trailing checks are regularly used by street supervisors to investigate operational problems. At one study system, schedulemakers are required to trail selected trips on a line to verify running times before rebuilding headways. One other larger system indicated that it intended to introduce a similar procedure, but the exact nature of this program has not been finalized. It is also noted that trailing checks may be conducted as part of systemwide comprehensive route and scheduling studies carried out periodically every few years by transit systems. None of the forty-one study systems utilized trailing checks on a regular bais; however, most do conduct them occasionally for the purposes described above.

3.3.4 Farebox Data Collection

Many transit systems currently employ registering farebox systems of varying sophisication which permit revenue data to be obtained without counting money.[1] The most sophisticated farebox systems have the added capability of recording number of passengers by type of fare paid, either automatically or with operator intervention for special fare types. Using

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[1]At systems without registering boxes, revenue by block can be obtained only by counting or recording the receipts of individual vaults. The use of electronic fareboxes for automated data allocation is discussed in Section 3.4, "Automated Data Collection Systems."

farebox readings to obtain passenger counts may result in data quality problems, however, due to the amount of operator involvement which is required when the fare structure is complicated. Interestingly, the latest model of a more sophisticated multiple register farebox system also has the capability to automatically record magnetic strip passcard transactions.

The collection of farebox data may be accomplished in three ways; in order of decreasing applicability for the determination of route revenues, these are:

- recording of farebox register readings by the operator by trip or when a bus changes lines;
- recording of farebox register readings at pull-out and pull-in on a regular basis by either the operator or garage personnel; or
- pulling of farebox vaults at pull-out and pull-in to count and record revenue by bus.

As shown in Table 3.12, seven of the forty-one study systems require operators to record farebox revenue by trip and nine require less frequent recording, primarily at pull-out and pull-in. At ten other systems, farebox revenue by bus is recorded by someone other than the operator at pull-out and pull-in, either on a regular basis by reading the farebox registers, or less frequently by pulling farebox vaults. Overall, twenty-six or two-thirds of all study systems record farebox revenue data (from which route revenue estimates may be derived). However, of these twenty-six, only eighteen actually calculate route revenue on a regular basis. (See Table 3.13.) Where route revenue estimates are not computed, extensive interlining seems to be the primary reason for not using farebox data to generate route-specific revenue. In a number of instances, only systemwide revenue information was felt to be needed for management financial reporting purposes; route revenue data was not of interest for this or other operational uses.

Table 3.12

FAREBOX DATA COLLECTION BY STUDY SYSTEM SIZE GROUP

Number of Peak Buses	Number of Study Systems	Operator Farebox Readings		Farebox Readings by Others	Pull Vaults*	Total	Percent
		By Trip	Other				
Fewer than 100	8	4	-	2	-	6	75%
100 to 249	10	2	3	1	-	6	60
250 to 399	6	1	3	1	-	5	83
400 to 749	10	-	2	2	1	5	50
750 and Over	7	-	1	-	3	4	57
TOTAL	41	7	9	6	4	26	63%

*Vaults are pulled and revenue is recorded separately for each vault; this is not usually done on a regular basis.

Table 3.13

STUDY SYSTEMS ESTIMATING REVENUE BY ROUTE

Number of Peak Buses	Farebox Revenue	Revenue by Route
Fewer than 100	6	4
100 to 249	6	3
250 to 399	5	5
400 to 749	5	3
750 and Over	4	3
TOTAL	26	18

3.3.5 Use of Operators for Additional (Non-Farebox) Data Collection

The use of operators for service monitoring data collection varies considerably for study systems. Overall, thirty-four of the forty-one study systems use operators for data collection, with about one-half of the study systems doing so on a regular basis and the remainder on an occasional basis for special counts. (See Table 3.14.) The types of data collected by operators on a regular basis are shown in Table 3.15 (including farebox readings, as discussed in the previous section). As shown by Table 3.15, twelve of the study systems have operators record passenger boarding counts. Four of the systems with fewer than 100 buses record this information after each trip and have no other point or riding check program. Counts are made either by manual recording of boarding passengers or through the use of digital counters mounted on the farebox. A total of nine study systems collect passenger type information on a regular (mostly daily) basis. In addition, two study systems reported using operators to record only special fare passengers, one daily and the second quarterly.

Table 3.14

USE OF OPERATORS FOR SERVICE MONITORING DATA COLLECTION

Number of Peak Buses	Number of Study Systems	Use Operators Regularly		Use Operators	
		Number	Percent	Number	Percent
Fewer than 100	8	6	75%	7	88%
100 to 249	10	7	70	9	90
250 to 399	6	4	67	5	83
400 to 749	10	3	30	8	80
750 and Over	7	3	43	5	71
TOTAL	41	23	56%	34	83%

Table 3.15

TYPE OF DATA COLLECTED BY OPERATORS

Number of Peak Buses	Regular Use of Operators	Farebox Readings		Passenger Counts		Special Counts
		By Trip	Other	Total	By Type	
Fewer than 100	6	4	-	6	5	2
100 to 249	7	2	3	4	4	-
250 to 399	4	1	3	1	1	2
400 to 749	3	-	2	1	-	1
750 and Over	3	-	1	-	1	1
TOTAL	23	7	9	12	11	6

One larger system regularly uses operators to count the number of on-board passengers at selected time points along the route.

Six systems carry out annual, semi-annual, or quarterly systemwide ridership studies using operators. Each system employs a different survey approach for these special studies:

- one collects boarding passenger counts twice per year for all trips
- one conducts an O-D survey and boarding passenger count annually
- three collect detailed rider characteristic data by trip; one on an annual basis and two quarterly
- one records the number of pasengers on board at selected time points for each trip for one week each year

At study systems where operators collect data regularly or on an occasional basis, typically special ridership counts are made on an "as needed" basis in response to local service planning, scheduling, and management reporting requirements. (One small Midwest system has developed a unique approach for Section 15 reporting which is noteworthy in this regard. To estimate passenger-miles based on ridership for a selected sample of trips, operators record the number of passengers on-board at mileposts installed along the route. To meet sample size requirements, each operator is required to count passengers in this manner for approximately one trip per month.)

The quality of data being collected by operators was questioned in discussions with study systems. Usually, if the the quality of data collected by operators is suspect, the systems do not use operators for data collection on a regular basis. Only three systems with regular operator data collection by trip considered the data quality to be poor; one of these systems operates fewer than 100 buses during peaks, and at both other systems, the data collected by operators are only part of the overall service monitoring data collection program.

3.3.6 Surveys

Study systems conduct a variety of data collection surveys which are not carried out on a regular basis. The most common types of special data collection activities are:

- passenger origin-destination surveys which may be carried out every few years or in connection with the introduction of new services;
- transfer surveys which provide an estimate of transfer rates between route pairs, the level of transfer activity at various locations, and the distribution of the number of transfers per linked trips;
- passenger socioeconomic characteristics survey which may be used in marketing and evaluating service for special passenger types (e.g., the handicapped);
- passenger attitudinal surveys which provide a qualitative understanding of level-of-service and its impact on usage; and
- passenger by type counts for average fare estimation where registering farebox data are not available.

3.4 Automated Data Collection Systems

Recently, there has been considerable research and development related to the implementation of automated data collection systems for collecting passenger load, schedule adherence, and running time data. The state-of-the-art has been moving ahead rapidly and, as shown in Table 3.16, one study system, the Ottawa-Carleton Regional Transportation Commission, has an operational system, while six others are in various stages of testing and development activities.

Five general types of automated systems can be identified:[1]

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[1]For further detail, see Murray, William S., Automatic Passenger Counter Test Results, MITRE Corporation, prepared for UMTA, December 1975.

Table 3.16

CURRENT AND PLANNED USE OF AUTOMATED DATA COLLECTION SYSTEMS

Number of Peak Buses	Number of Study Systems	Operational	Testing	Interest or Planning	Total	Percent
Fewer than 100	8	-	-	-	-	-
100 to 249	10	-	-	3	3	30%
250 to 399	6	-	1	2	3	50
400 to 749	10	1	2	7	10	100
750 and Over	7	-	3	3	6	86
TOTAL	41	1	6	15	22	54%

- infrared beam interruption systems;
- ultrasonic beam interruption systems;
- acoustic echo ranging systems;
- multi-switch treadle systems; and
- pressure-sensitive mat systems.

Each of these systems is designed to sense and record passenger boarding and alighting activity. The state-of-technology of these systems has advanced considerably in the past two years. Their use in the transit industry may be widespread in the future as hardware and systems capabilities are refined. Two types of systems are under development at the present time and have been deployed on a limited basis at North American transit properties. The first type of system provides for automated collection of passenger count and running time information using on board data collection and storage units. For data analysis and recording, data collected on tape cassettes or other devices must be transferred to a central processing location for data interpretation and validation.

The second type of system, referred to as Automated Vehicle Monitoring (AVM), provides for more comprehensive data collection with real-time data displayed and recorded for dispatching and street supervision purposes. Data collection from on board sensors is transmitted via a bus radio system to a central location at regular intervals of every few seconds. Automated passenger count systems are operational at several North American properties, while major AVM system development projects are underway in Los Angeles, Cincinnati, and Toronto.

As shown in Table 3.16, most medium and large systems have at least an interest in automated data collection systems. For systems with a large number of checking personnel, automated data collection may offer both modest cost savings and expanded data collection programs.[1] However, it is still unclear as to which technique (automated versus manual) offers greater

---

[1]For example, at OC Transpo, checking personnel requirements have been reduced from eight to two persons with the implementation of automated data collection.

data accuracy. (Recently published UMTA test data indicates that 90% accuracy may be expected for boarding and alighting counts and that over 95% of on-board counts should be within $\pm$ 2 passengers.[1] At OC Transpo, accuracy exceeding 95% for boarding and alighting movements is being reported.)

Of the seven study properties operating or testing automated data collection programs, three are using on-line AVM systems. Systems in Cincinnati and Toronto are currently operational on a test basis; in addition, development work is underway for a major UMTA-sponsored demonstration project at the Southern California Rapid Transit District (SCRTD). Automated data collection systems with off-line data retrieval and processing are currently being installed for less than $2,500 per bus. At OC Transpo and four other authorities including the SCRTD, data collection systems with off-line data retrieval and processing are being used.

Automated Farebox Systems

Although none of the study systems interviewed had implemented an automated farebox system, use of such systems may become significant in the next few years. It was therefore considered important to consider them in this study. At this writing, a sophisticated electronic farebox system was being installed at the Bi-State Development Agency transit system in St. Louis, Missouri. Each farebox is equipped with a microprocessor which monitors revenue and passenger boardings by special fare category. An additional component can be attached to record this information by route, operator, and time-of-day through use of magnetic cards. When the bus pulls in to its garage, all data stored in the farebox may be electronically

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[1]A. L. Balaram et al., Evaluation of Passenger Counter System for AVM Equipment, Final Report, prepared for the U.S. Department of Transportation, Urban Mass Transportation Administration, February 1979.

transferred to a central computer where they are processed, analyzed, and printed out in an easy-to-read form, thus bypassing the need for operators or checkers to record any data.

3.5 Service Monitoring Costs and Staff Requirements

Information concerning service data collection budgets or expenditures was solicited in telephone discussions with study systems but only a few systems were able to provide this information. At many study systems, service data collection is not treated as a separate budget item but is included as part of the overall scheduling and service planning budgeted expenditures. Also, it is difficult in most instances to isolate data collection costs where transportation marketing, accounting, and other personnel are collecting or assembling selected data items as part of overall job responsibilities. Thus, most study system respondents were not able to furnish good estimates of service monitoring costs; however, the costs associated with regular checking staffs and operator and supervisor data collection can be estimated and should serve as a reasonable approximation of the resources expended by study systems for service monitoring.

None of the study systems with fewer than 100 buses employs regular checking staffs; service monitoring data collection is typically carried out by supervisors or operators on a programmed or "as needed" basis. (See Table 3.17.) For collecting detailed passenger or farebox information by trip, six study systems provide for extra operator pay ranging from $.25 to about $3 per day. At other systems, data collection is considered part of the operators' regular duties. Additionally, several systems use temporary personnel from time to time to assist in carrying out regular and special data collection programs.

As would be expected from the wide diversity of data collection programs, there is substantial variation in the number of regular checking personnel employed by individual

Table 3.17

STUDY SYSTEMS WITH REGULAR CHECKING PERSONNEL BY SIZE GROUP

Number of Peak Buses	Number of Study Systems	Systems with Regular Checking Personnel	
		Number	Percent
Fewer than 100	8	-	-
100 to 249	10	8	80%
250 to 399	6	4	67
400 to 749	10	9	90
750 and Over	7	7	100
TOTAL	41	28	68%

systems, as shown in Table 3.18. This table, showing the number of full-time equivalent checkers per 100 peak buses operated for each study system size group, indicates that checking staff sizes range considerably from one to three checkers per 100 peak buses for most of the study systems included in the table;[1] in dollar terms, this represents a range of roughly $160 to nearly $500 annually per peak bus operated.[2]

Table 3.18

NUMBER OF CHECKING PERSONNEL BY STUDY SYSTEM SIZE GROUP

Number of Peak Buses	Checking Personnel Per 100 Peak Buses				
	Fewer than 1	1-2	2-3	More than 3	Total
100 to 249	2	1	3	1	7
250 to 399	-	3	1	-	4
400 to 749	-	3	2	-	5
750 and Over	1	2	3	1	7
TOTAL	3	9	9	2	23

An analysis was conducted of the costs of utilizing each of the data collection techniques described in this chapter. Not surprisingly, costs varied significantly among systems. This variation is so extensive that it was considered meaningless to specify the costs of each technique, except to say

[1]Five study systems with checking staffs but without regular point or riding check programs have not been included in this table since these systems rely on either operator or automated data collection, or collect data only on an "as needed" basis.

[2]Assuming $16,000 annually for checker wages and fringe benefits. Actual costs vary from system to system.

that, generally, riding checks are more expensive to conduct than are point checks. In addition, it is clear that the costs depend on the characteristics of system design (e.g., route layout, number of buses) and thus must be calculated individually for each property.

Chapter 4

IMPLICATIONS OF RESULTS

As noted earlier, the objective of this study is to develop a data collection system which allows transit properties to collect the data in which they are interested in a cost-effective manner and in a manner which maximizes the usefulness of the overall data base. The data that are needed to develop measures of interest were identified in Chapter 2 of this report. The present methods of collecting data were identified in Chapter 3. This information forms the basis upon which to attempt to build more cost-effective data collection strategies.

Table 4.1 attempts to integrate the results of the previous two chapters in a relatively concise form which will be of assistance in future project tasks. The table indicates the <u>data collection techniques</u> available for each of the <u>data items</u> identified in Chapter 2. In addition, various issues related to data collection are noted. The data are arranged in the same order in which they appear in Chapter 2. While this gives a somewhat random quality to the table, it facilitates the use of Table 4.1 in conjunction with the tables of Chapter 2.

The table addresses several issues of major importance for this study. It identifies the full range of data collection technqiues available to collect each data item. In so doing, it facilitates the analysis of how the collection of different data items might be coordinated. It also indicates how different data collection techniques can be used to collect the same data, thus facilitating the analysis of the cost-reliability trade-off (an important issue to be addressed in the following task). All of this will contribute to the main focus of the monitoring system design: identifying the most efficient data collection techniques.

Table 4.1 also touches on some of the measurement problems identified by properties. Perhaps foremost among them is the general problem of aggregation. For example, many properties are interested in measuring the performance of different routes. However, a variety of factors, such as interlining, may make it difficult to develop measures on a route-specific basis. Similarly, many properties want to estimate ridership by fare category, both for estimating average fare (on a route specific basis) and to determine how different market groups are being served. Finally, some properties would like to consider performance at different times of day, but focus limited resources on peak hour service.

These factors all point to the need for the data collection program to retain flexibility with regard to differing property needs and constraints. It must simultaneously provide a methodology for collecting passenger-related performance data in a cost-effective manner, and at the same time, provide a framework for tailoring that methodology to individual properties. In addition, it must allow some flexibility in the choice of data to be collected and in the manner in which the data are processed.

Finally, it became clear that many of the current problems with data collection are a function of a single factor: the lack of a clear understanding of sampling requirements as a function of desired confidence and acceptable errors. The study is intended to develop a data collection plan which maximizes the benefit received from a minimum amount of data. If an improved sampling plan can be developed for all data items (and if data collection activities can be better coordinated), it may be possible for a property to accurately develop all desired measures utilizing existing data collection resources.

Table 4.1

POTENTIAL DATA COLLECTION TECHNIQUES FOR EACH DATA ITEM

Data	Techniques	Comments
1. Number of passengers on bus	Point checks Riding checks Operator-collected data	
2. Bus arrival time	Point checks Riding checks Trailing checks Operator-collected data	Would typically measure across several days
3. Time each passenger stands	Riding checks Operator-collected data	Very difficult to measure; not presently done
4. Number of passengers transferring between route pairs	Point checks	Only possible if checks are conducted at transfer points
	Transit records	Only if transfers are issued and identifiable by originating and terminating route
5. Passenger-trips by route	Riding checks	
	Farebox data collection Operator-collected data	Only if farebox has ability to count passengers, including special-fare categories
6. Boarding passenger arrival time	Point checks	Not typically done

Table 4.1

POTENTIAL DATA COLLECTION TECHNIQUES FOR EACH DATA ITEM

(continued)

Data	Techniques	Comments
7. Revenue by route	Farebox data collection	Separable by route only if either: (1) interlining is minimal; or (2) farebox readings can be recorded each time a bus is interlined
8. Passenger boardings and alightings by stop	Riding checks	
9. Socioeconomic characteristics of passengers	Surveys	On-board, mail-back
10. Travel patterns of passengers	Surveys	On-board, mail-back
11. Origins and destinations of passengers	Surveys	On-board, mail-back
12. Attitudes toward and perceptions of transit service	Surveys	On-board, mail-back, telephone, home interview

Appendix A

LIST OF TRANSIT PROPERTIES INTERVIEWED

1. Albuquerque, New Mexico
2. Allentown, Pennsylvania
3. Atlanta, Georgia
4. Baltimore, Maryland
5. Buffalo, New York
6. Canton, Ohio
7. Champagne-Urbana, Illinois
8. Chapel Hill, North Carolina
9. Chicago, Illinois
10. Cincinnati, Ohio
11. Dade County, Florida
12. Denver, Colorado
13. Des Moines, Iowa
14. Edmonton, Alberta
15. Houston, Texas
16. Jacksonville, Florida
17. Kansas City, Missouri
18. Los Angeles, California
19. Milwaukee, Wisconsin
20. Minneapolis,St. Paul, Minnesota
21. Montgomery, Alabama
22. Nashville, Tennessee
23. Oakland, California
24. Omaha, Nebrasks
25. Orange County, California
26. Ottawa, Ontario
27. Phildelphia, Pennsylvania
28. Phoenix, Arizona
29. Portland, Oregon
30. Providence, Rhode Island
31. Regional Transit Authority (RTA) Chicago, Illinois
32. Rochester, New York
33. Salt Lake City, Utah
34. San Antonio, Texas
35. San Diego, California
36. San Mateo, California
37. Seattle, Washington
38. Tidewater, Virginia
39. Toronto, Ontario
40. Washington, D.C.
41. Yakima, Washington

Appendix B

My name is ____________________ with ATE Management and Service Company in _________________. We are currently engaged in a contract with the Urban Mass Transportation Administration in association with the Multisystems, Inc. of Boston. The contract is concerned with how transit systems are monitoring service performance and, specifically, what data is being collected for service performance monitoring. You may have recently been contacted by mail by either the MBTA or TTC, and this telephone call is a follow-up to your response to the mail questionnaire.

(ASK ABOUT EACH OF THE FOLLOWING TYPES OF DATA)

- Passenger loads
- Schedule adherence
- Running times
- Route ridership
- Route revenues
- Route costs
- Transfers
- Rider characteristics

(FOR EACH DATA CLASS)

What techniques do you use to collect data on _________ _______________? Exactly what data do you collect? How is this data used? What resources (manpower and other costs) are expended in collecting the data?

DATA CLASS ____________________

What technique is used to collect data?____________________

____

____

Exactly what data is collected?____________________

____

____

How is this data used?____________________

____

____

What resources (manpoiwer and other costs) are expended in collecting this data?____________________

____

____

Do you need to allocate revenue by community? How do you do it?

____

____

____

How do you estimate revenue by fare category? ____________________

____

____

To what extent do you have no-fare passengers (e.g. passes, elderly, etc

____

(FOR EACH DATA CLASS IF NOT ANSWERED IN DISCUSSING TECHNIQUE)

How would you rate the importance of this data for your operation?________________________________

____

How accurate do you think this data must be? How accurate do you think your data are? Do you perform any reliability checks on the data? How?________________________________

____

____

What are the problems you see with collecting this type of data? What do you think a solution might be? Why hasn't it been implemented before?

____

____

____

Are you aware of any other interesting data collection techniques for this type of data?

____

____

____

Automated data collection? ______________________

____

What additional data would you like to collect

in this area? Why? ______________________________

____

____

(OBTAIN CHECKING PERSONNEL AND GENERAL SYSTEM INFORMATION)

STANDING/POINT CHECKS

1. Do you have a regular program?___________

How established (be specific)?___________

____

____

____

2. Which locations are checked? ___________MLP___________

Branch points?___________Other?___________

3. How often are lines checked?___________

____

Does this correspond with picks?___________How many days per check?___________Consecutive days?___________

How selected?___________Peak Periods only?___________

All day?___________ Other?___________

Are Saturdays/Sundays checked?___________

4. Are check sheets precoded?___________

Block numbers?___________Scheduled times?___________

Computerized?___________

5. Does checker analyze data on the street? How?___________

____

____

Are all checks validated for missing data?___________

Who validates?___________

Computerized?___________

RIDING CHECKS

1. Do you have a regular program ?________________

How established (be specific)? ________________

____

____

Which lines?________________

How often?________________

How many trips per line?________________

How selected?________________

2. Purpose? Service Analysis?________________

____

Running times?____ ________________

Section 15 reporting?________________

Small lines instead of point check?________________

Other?________________

____

3. What data collected? Boardings/alightings by stop/

segment/trip?________________Passenger type?

____

Fare type?________________

Time at timepoints?________________

Transfers by stop/trip?________________Farebox?________________

4. Who conducts riding checks? Checkers? ______________________

Temporary/outside staff? ______________________________________

Budget/mandays for riding checks? _____________________________

5. How is data analyzed? ______________________________________

____

Who analyzes? ____

Brownsheeted? ____

Summarized by route segment and time of day? __________________

Historical/trend analysis? ____________________________________

Management summary reports? ___________________________________

____

6. Computerized? ______________________________ How is

data entry accomplished? ______________________________________

____

What system? ____

Are programs available with documentation for others? ________

____

What is annual budget for data entry and processing? _________

____

7. Can you provide copies of your data collection and

analysis sheets? ________________ Can you provide example

management information reports? ______________________________

Is the data available? ____

In what form? ____

____

____

8. What share of your total service checking budget is for riding checks? ____________________ Is your riding check program adequate? ____

OPERATOR CHECKS

1. Do operators record passenger, revenue, or transfer data on a regular or special basis? ______________________

____

2. Is this recognized in the union agreement as a basis for compensation? ______________________

Is additional compensation paid? ______________________

How much? ______________________

How much is budgeted annually in extra operator compensation for checks? ______________________

How funded? ______________________

3. Do operators record boarding passengers? ______________________

How often? ______________________ Which lines or line segments? ______________________

____

____

Are passengers counts recorded by stop trip. or line segment? ______________________

How recorded? ______________________

____

4. Do operators record passengers by type? ______________________

How often? ______________________ Which lines or line segments?

____

How recorded? ______________________________

Traffic counters? ______________________________

Farebox registers? ______________________________

Other? ______________________________

5. Do operators record revenue/transfers? ______________________________

How often? ______________________________

Which lines or line segments? ______________________________

By trip or run? ______________________________

How recorded? ______________________________

____

6. How is this data analyzed (be specific)? ______________________________

____

____

____

7. What is your assessment of the data quality? ______________________________

____

____

8. Have you considered using operators for data collection or expanding their current data collection responsibilities? Why? ______________________________

____

____

____

SPECIAL SURVEYS

Do you conduct special surveys of the following type (Please describe)?

O-D Surveys? ____

____

____

Transfer Surveys? ____

____

____

Passenger Attitudinal Surveys? ____________________________

____

____

Other? ___ ____

____

____

CHECKING PERSONNEL

Do you have a regular staff for service data collection?

____

Which department is responsible for these personnel?

____

How many checking personnel?

Full-time ______________

Part-time ______________

Temporary (see below) __________

If part-time staff, how many hours/days worked in preceding 12 months? ______________________________

Are checking personnel union employees? ______________

Operators? ______________

Office? ______________

What is hourly/annual pay rate for checkers? __________

What is operator's base pay rate? ______________

How many checkers have worked over 5 years? __________

2 years? ______________ One year? ______________

How are checkers supervised? ______________

____

What is the total budget for checking personnel? __________

Is there more or less than two years ago? ______________

Do you use temporary staff? ______________

How obtained? ______________ Pay rate? ______________

GENERAL SYSTEM INFORMATION

What is your annual operating budget?____________________

What is the annual operating subsidy?____________________

How many lines do you operate? ____________________

Bus?____________________ Rail?____________________

Has this changed in the past one year?____________________

Two years?____________________

How many divisions?____________________

How many buses operated in peak period?____________________

am or pm?____________________

What is your average monthly revenue/ridership?

____________________How much has this changed

in past six months?____________________

One year?____________________ Two years?____________________

How much is it forecast to change in the next 12 months?

____

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