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TCRP Synthesis 29

Passenger Counting Technologies And Procedures

A Synthesis of Transit Practice

Transportation Research Board
National Research Council

TRANSIT COOPERATIVE RESEARCH PROGRAM

Synthesis of Transit Practice 29

Passenger Counting Technologies And Procedures

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Transportation Research Board
National Research Council

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TRANSIT COOPERATIVE RESEARCH PROGRAM

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

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

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

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

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

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

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

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

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PREFACE

A vast storehouse of information exists on many subjects of concern to the transit industry. This information has resulted from research and from the successful application of solutions to problems by individuals or organizations. There is a continuing need to provide a systematic means for compiling this information and making it available to the entire transit community in a usable format. The Transit Cooperative Research Program includes a synthesis series designed to search for and synthesize useful knowledge from all available sources and to prepare documented reports on current practices in subject areas of concern to the transit industry.

This synthesis series reports on various practices, making specific recommendations where appropriate but without the detailed directions usually found in handbooks or design manuals. Nonetheless, these documents can serve similar purposes, for each is a compendium of the best knowledge available on those measures found to be successful in resolving specific problems. The extent to which these reports are useful will be tempered by the user's knowledge and experience in the particular problem area.

FOREWORD
By Staff
Transportation
Research Board

This synthesis will be of interest to transit agency general managers, their planning and scheduling, operations and maintenance, computer services, and budget and finance staffs, as well as to technology providers. It summarizes information from selected transit agencies about benefits and problems associated with each passenger counting technology, as reported by current users. It also presents advice for agencies considering each technology.

Administrators, practitioners, and researchers are continually faced with issues or problems on which there is much information, either in the form of reports or in terms of undocumented experience and practice. Unfortunately, this information often is scattered or not readily available in the literature, and, as a consequence, in seeking solutions, full information on what has been learned about an issue or problem is not assembled. Costly research findings may go unused, valuable experience may be overlooked, and full consideration may not be given to the available methods of solving or alleviating the issue or problem. In an effort to correct this situation, the Transit Cooperative Research Program (TCRP) Synthesis Project, carried out by the Transportation Research Board as the research agency, has the objective of reporting on common transit issues and problems and synthesizing available information. The synthesis reports from this endeavor constitute a TCRP publication series in which various forms of relevant information are assembled into single, concise documents pertaining to a specific problem or closely related issues.

This document from the Transportation Research Board reports on the ranges of techniques to count passengers and estimate ridership. Issues considered deal with data collection methodology, data processing, end uses of ridership data, organizational responsibilities, and resource requirements.

To develop this synthesis in a comprehensive manner and to ensure inclusion of significant knowledge, available information was assembled from numerous sources, including a number of public transportation agencies. A topic panel of experts in the subject area was established to guide the researchers in organizing and evaluating the collected data, and to review the final synthesis report.

This synthesis is an immediately useful document that records practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As the processes of advancement continue, new knowledge can be expected to be added to that now at hand.

CONTENTS

1 SUMMARY

4 CHAPTER ONE INTRODUCTION
Background, 4
Purpose and Scope, 4
Literature Review, 5
Organization of the Synthesis, 5

7 CHAPTER TWO WHY COLLECT RIDERSHIP DATA?
Definition of Ridership, 7
Uses of Ridership Data, 7
Summary, 8

9 CHAPTER THREE PASSENGER COUNTING TECHNOLOGIES AND PROCEDURES
Frequency of Ridership Counts, 9
One Hundred Percent Versus Sample Counts, 9
Passenger Counting Technologies and Procedures, 9
Summary, 14

15 CHAPTER FOUR PROCESSING AND REPORTING
Data Input, 15
Data Validation, 15
Data Reports, 15
Summary, 16

17 CHAPTER FIVE ORGANIZATION AND RESOURCE REQUIREMENTS
Organization, 17
Staffing, 17
Cost, 17
Summary, 18

19 CHAPTER SIX TECHNOLOGY PROVIDERS' PERSPECTIVE
Technology Providers Interviewed, 19
Perspective on Transit Industry Applications, 19
Summary, 20

21 CHAPTER SEVEN CASE STUDIES
Metropolitan Transit Authority of Harris County, Texas, 21
Tidewater Transportation District Commission, 23
Chicago Transit Authority, 24
Tri-County Metropolitan Transportation District of Oregon, 25
Ottawa-Carleton Regional Transit Commission, 27
South Coast Area Transit, 29

31 CHAPTER EIGHT CONCLUSIONS

33 REFERENCES

34 APPENDIX A SURVEY QUESTIONNAIRE AND RESPONSES

48 APPENDIX B LIST OF SURVEY RESPONDENTS AND TECHNOLOGY FIRMS INTERVIEWED

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PASSENGER COUNTING TECHNOLOGIES AND PROCEDURES

SUMMARY

The transit industry has a long history of counting passengers on its buses. From paper and pencil, still in use at many agencies today, technologies have evolved to include handheld units, electronic registering fareboxes (ERFs), automatic passenger counters (APCs), and smart cards. As detailed analyses of system, route and sub-route ridership data become a standard way to identify opportunities to reallocate scarce resources in times of fiscal constraints, transit agencies today face more choices than ever in terms of how to count their passengers. Complicating the issue is the fact that no one method works best for all purposes.

The purpose of this synthesis is to examine the current state of the practice in terms of passenger counting technologies and procedures. Survey results from 33 transit agencies provide information on a variety of topics, including the purposes of collecting ridership data at various levels, technologies and procedures currently in use or planned, data input and retrieval, analysis and reporting of ridership data, organizational issues, resource requirements (including staffing and cost), and benefits and problems associated with each technology. The transit agencies included in the survey range in fleet size from 46 to 2,155 buses and have experience, in terms of day-to-day use or demonstration projects, with every technology currently in use in North America.

The synthesis also provides insight from the perspective of companies supplying passenger counting technologies and equipment to the transit industry. Interviews were conducted with five companies specializing in passenger counting technology to obtain their views regarding factors contributing to successful adoption of new technologies at transit agencies. Finally, case studies were conducted through detailed telephone interviews with six agencies that represent the spectrum of passenger counting technologies. The case study agencies include:

- Metropolitan Transit Authority of Harris County (METRO) in Houston, Texas,
- Tidewater Transportation District Commission (TTDC) in Norfolk, Virginia,
- Chicago Transit Authority (CTA) in Chicago, Illinois,
- Tri-County Metropolitan Transportation District of Oregon (Tri-Met) in Portland, Oregon,
- Ottawa-Carleton Regional Transit Commission (OC Transpo), in Ottawa, Ontario, Canada, and
- South Coast Area Transit (SCAT), in Oxnard, Ventura County, California.

Houston METRO is an example of an agency that uses ERFs for system and route-level ridership estimates and manual pencil and paper procedures for trip-level analyses in developing an effective ridership data collection program that meets the agency's needs. TTDC pioneered the use of hand-held data collection on its system. CTA has recently concluded an extended process of considering advanced passenger collection technologies with

an APC demonstration, and has been an industry leader in making effective use of farebox data. Tri-Met is integrating its existing APC data collection system with a new GPS-based automated vehicle location (AVL) system. Ottawa is in its second decade of relying on a signpost-based APC system for virtually all of its ridership data. South Coast Area Transit is one of the first agencies to undertake an extensive smart card demonstration project on its bus system.

The synthesis summarizes benefits and problems associated with each passenger counting technology, as provided by current users, and also presents advice for agencies considering each technology. The case studies are able to go into greater detail on these issues, especially on how problems have been resolved. Case study agencies and technology providers are in agreement on many key points related to the adoption of new technologies by transit agencies.

Primary conclusions of this synthesis include the following:

- *Procedures are more important than technology*--*Experience* to date strongly suggests that establishing and adhering to data collection procedures that meet the agency's needs is the most critical factor, regardless of the technology selected to count ridership. There is a tendency within the industry to focus too much on the hardware side and not enough on the need and uses for ridership data within an agency.
- *Internal changes are necessary to ensure the success of new passenger counting technologies*--*A* significant investment in time and effort is needed in the early stages to update internal databases and analytical techniques, to ensure that the system receives the priority it needs, and to train staff in its maintenance and usage.
- *Visit and learn from other agencies before deciding on a new passenger counting technology*--*This* emerged as a strong recommendation from both the surveys and the case studies. While each agency obviously has unique aspects, the process of implementing new passenger counting technologies is very similar throughout the industry. Instead of reinventing the wheel, a savvy agency can draw on the experiences of others in planning its own implementation of new technology.
- *Unnecessary customization should be avoided*--*This* phenomenon is related to the emphasis on technology seen within the transit industry. Attempts to redesign what is available on the market to make one's own system unique or better almost always result in failure. Most installations require a fair degree of customization to match agency needs, but taken to extremes, this is a recipe for failure.
- *A strong commitment from senior management is required*--*Adoption* of new passenger counting technologies and procedures involves changes in departmental functions and responsibilities. Support from the general manager raises the priority attached to passenger counting and ensures cooperation among the various departments involved.
- *Active management of the passenger counting system is critical to success—Senior* management support is vital, but agencies that have successfully adopted new technologies are characterized by a mid-level person who assumes responsibility for the system and takes the necessary action to ensure its proper functioning.
- *Responsibilities must be clarified*--*Adopting* a new technology is not a step taken in isolation. Internal working relationships (between planning and dispatching, for example) are likely to change noticeably. Cooperation from several departments within the agency is needed, and does not necessarily happen overnight. Clarification of responsibilities at the outset is advised by agencies that have been through the process.
- *Advanced passenger counting technologies offer several benefits*--*Among* benefits cited by survey and case study agencies are more frequent data collection, a reduction in turnaround time, the ability to analyze ridership data at finer levels of detail, greater timeliness and responsiveness, and lower cost. These do not accrue automatically; the most successful

agencies have updated internal databases and adapted procedures to maximize the benefits offered by advanced technologies.

- *There is no one perfect solution--Agencies* must consider their need for and uses of ridership data before deciding how best to proceed. Each ridership counting technology is appropriate to use for certain purposes, and there are successful examples of each in the case studies. Many agencies using manual techniques are satisfied with established data collection schedules and have been successful in meeting the needs of data users. One hundred percent accuracy does not exist with any technology. New passenger counting technologies have a break-in period of approximately 18 months during which start-up problems are identified and solved.

Integration of passenger counting technologies with other emerging technologies (e.g., integration of APCs with AVL systems) is a developing trend. The number of agencies that are at least considering new technologies suggests that the state of the practice is likely to undergo considerable changes within the next decade.

CHAPTER ONE

INTRODUCTION

BACKGROUND

Passenger counting to estimate ridership is a significant component of transit service planning, scheduling, and forecasting. Ridership is a key measure of transit agency effectiveness and an important factor in analyzing performance and productivity (using measures such as passengers per revenue mile or cost per passenger). Transit agencies count their passengers in many different ways, varying from manual counting to a variety of automated counting technologies, such as the use of electronic fare collection and automatic passenger counters (APC).

Most agencies rely, singly or in combination, on manual counts, electronic fareboxes, and APCs. Manual passenger counting involves placing a traffic checker on the transit vehicle to record all boardings and alightings made on each trip. The checker usually notes the time at key time points along the route for the purposes of adjusting schedules. The information is recorded on a preprinted form that includes all of the stops along the route, or is entered into a hand-held unit preprogrammed to include all stops. Electronic registering fareboxes (ERFs) require operator intervention to count passengers. The operator hits one of a series of keys on a keypad connected to the ERF to indicate the type of fare paid by each boarding passenger, and must also enter a code to indicate the route, run number, and beginning of each trip. ERF data are generally collected at the trip level; stop-level information is not available. An APC automatically records passenger boardings and alightings through the use of beams or mats, associates a time with each stop, and locates the stop through signposts positioned throughout the system, from odometer readings, or via satellite.

Transit agencies count and aggregate ridership at different levels, depending on the type of data needed. Senior managers may be concerned primarily with systemwide ridership trends. Schedulers and planners need to know passenger loads at key points and by time of day along each route. Marketing and planning staff may need to know fare classification information. No single passenger counting procedure meets all of these needs.

Technological innovations and refinements have opened new possibilities in the realm of collecting transit ridership data Like all technological advances, these have been adopted by a few innovators within the industry whose experiences have been observed closely by other transit agencies. As the array of choices has broadened, decisions regarding which technologies and procedures should be deployed to count passengers have become more difficult. There is a clear need for information on how well various procedures meet the needs of individual transit agencies.

PURPOSE AND SCOPE OF THE SYNTHESIS

The objective of this synthesis is to report on the range of techniques to count passengers and estimate ridership. The following issues are considered:

- Data collection methodology is categorized as manual (using pencil and paper or hand-held units), electronic (via electronic registering fareboxes or "smart cards"), and APC-based. Different methodologies are often used for different purposes.
- Data processing involves the conversion or transmission of collected data to a format suitable for analysis. Steps in data processing can include manual input, electronic transmission, data editing or validation, report generation, and access to data.
- End uses of the ridership data often determine the most appropriate methodology to be used. In some cases, this relationship also works in reverse: new technologies can create ready access to data previously unavailable.
- Organizational responsibilities can be a major determinant in how well passenger counting technologies actually work. This is particularly true for newer technologies, which, because of their greater complexity, often require interdepartmental cooperation for successful implementation.
- Resource requirements are of primary interest, given the tight budgets prevailing in the transit industry. Costs, staffing needs, and skills are key elements of interest to all agencies.

These issues are addressed primarily by means of a survey sent in January 1997 to 36 selected transit agencies in the United States and Canada. Selection of agencies for the sample was guided by the presence of active, ongoing data collection activities, participation in similar studies or in national activities, adoption of innovative passenger counting technologies, and recommendations by other transit agencies. Representatives from these agencies were contacted prior to mailing the survey to enlist their cooperation. Follow-up calls were made as required to encourage survey completion. A total of 33 surveys were returned, yielding a response rate of 92 percent.

Case studies were conducted to supplement survey results. Six agencies representing a variety of passenger counting procedures were selected for in-depth telephone interviews. These interviews were intended to probe more deeply regarding issues raised by the survey results.

There is great interest in the transit community regarding the availability and capability of various passenger counting technologies. Members of the Topic Panel that guided this study and survey respondents identified technology providers, who contributed descriptive material regarding various products. Selected providers were interviewed to obtain their perspective on developments within the transit industry.

LITERATURE REVIEW

A review of current literature addressing passenger counting was also conducted as part of this synthesis and results are summarized here. While several reports provided extremely useful background information, the fast-changing nature of passenger counting technologies and procedures resulted in greater reliance on the 1997 surveys and case studies in synthesizing recommendations.

Hodges *(1)* prepared the first comprehensive overview of APC systems in a 1985 report detailing the state of the practice. The approach taken in this study involved the analysis of survey results from APC users and of findings from 13 case studies (seven in Canada, six in the United States). Three of the case study systems are also used in this synthesis (Chicago Transit Authority, Ottawa-Carleton Regional Transit Commission, and Tri-Met). The study's assessment of intended uses and benefits of APC systems is still of interest, but technological improvements over the past decade make other elements in the report outdated.

A more recent 1992 report on Advanced Public Transportation Systems by Labell, Schweiger, and Kihl *(2)* updated the state of the practice in terms of new technologies. Smart card demonstration programs were discussed in this report along with APC systems. By 1997, this report is also somewhat dated, given the developments over the past 5 years.

Rossetti *(3)* describes the feasibility of an automatic transit monitoring system based on radio frequency identification (RF/ID) of transit users. The prototype developed in this 1996 IDEA (Innovations Deserving Exploratory Analysis) project integrates automatic passenger counting, automatic vehicle location, and fare payment via RF/ID tags incorporated directly into bus passes. Much of the demonstration project is taken up with testing how well the vehicle location component works. RF/ID passes were tested only in simulation, although riders were surveyed regarding attitudes toward such passes. If successful, this system promises boarding/alighting data by passenger. Since AVL technology has been proven in the field, a more useful test would have involved how well passenger counting and passenger-specific boarding and alighting data are integrated and reported at the stop level. The issue of how to count passengers not using an RF/ID encoded pass is not addressed.

Greneker et al. (4) describe in a 1996 IDEA report an experimental transit vehicle passenger counter designed from off-the-shelf systems and field-tested in a bus. The experimental system is intended to permit origin-destination data to be collected for individual passengers by recognizing footprint patterns of boarding and alighting riders. As with existing APC mat-based systems, the experimental system was able to identify entering and exiting passengers. The goal of determining if the passenger is a man, woman, or child was not achieved. This study concludes by proposing use of a radar unit instead of floor mat sensors in a second phase of the study, although it is unclear whether the radar unit would be able to detect individual passenger movements and produce origin-destination patterns.

Boyle and Perk *(5)* reviewed procedures for data collection, analysis, and usage at operations planning departments of 20 major transit agencies as part of a study for Metro-Dade Transit Agency in Miami, Florida. This 1995 study addressed many of the elements analyzed in this synthesis, although many systems have instituted demonstration projects or implemented changes to their data collection procedures even in the 2 years since the study was published.

Several technology providers have published descriptions of their APC systems. These publications contain considerable technical detail on system components (6,7) as well as a non-technical overview of APC systems *(8).*

Finally, several agencies participating in this study provided results of their research into and experiences with passenger counting technologies. WMATA in Washington, D.C. provided a 1993 study on hand-held units (9) as well as an internal 1996 memorandum containing the results of a seven-agency survey related to usage of hand-held data collection devices *(10).* CTA made their 1996 APC agency and vendor contact lists available *(11);* these helped in the identification of agencies and vendors to be included in this study. OC Transpo provided a 1986 report *(12)* describing the evolution of APC at the agency over the previous 10 years and summarizing reasons for success. Key factors in success (that still, incidentally, apply today) include intra-agency cooperation, management commitment, the high caliber of hardware and software suppliers, and the APC experience developed within the agency. Lynx in Orlando, Florida sponsored a 1996 APC pilot study that included results of an APC-related survey of 25 transit systems *(13).* SCAT in Ventura County, California, sent along a newspaper article addressing privacy concerns related to the smart card demonstration project *(14).*

ORGANIZATION OF THE SYNTHESIS

Following this introductory chapter, chapter 2 discusses the reasons for collecting ridership data. Survey results support the need for specific information at the system, route, trip, and stop or segment levels. Chapter 3 forms the heart of the synthesis, summarizing the current state of the practice in counting riders. The extent of usage, capabilities, strengths and weaknesses of each technology, as noted by users, are reported in this chapter. Case study results are included as appropriate in this chapter to supplement the survey findings. Chapter 4 addresses processing and reporting issues related to passenger counting, including data input, data validation, and reporting capabilities. While processing and reporting techniques are not a direct subject of the synthesis, these issues need to be addressed to provide a more complete picture of the usefulness of various technologies in meeting agency needs.

Chapter 5 examines organizational and resource requirements within each transit agency for carrying out the passenger counting program. This chapter includes an analysis of the placement of the passenger counting function within each agency, and techniques for resolving and/or minimizing intra-agency conflicts. Staffing needs and capital, operating, and maintenance costs associated with the passenger counting function at each agency are summarized, although it should be noted that there is variation in the level of detail provided in these areas across different systems.

Chapter 6 provides basic information on the characteristics of available technologies as provided by the vendors identified by survey respondents or panel members. This is not intended as an all-inclusive inventory of technology providers, but as an example of various technologies that are being used by transit agencies included in the survey sample. The chapter also includes observations with regard to the application of these technologies in the transit industries from the suppliers' perspective.

Chapter 7 reports detailed findings from the six case studies. Agencies were selected for the case studies to represent different technologies and procedures. The case studies consisted of detailed telephone interviews, intended to elaborate on critical areas such as benefits, problems, and recommendations, with key agency personnel.

Chapter 8 summarizes the findings of the synthesis project and provides a "snapshot" of passenger counting technologies and procedures currently in use along with an assessment of their strengths and weaknesses. Findings from the surveys and particularly the case studies will be cited to support recommendations regarding the implementation and use of various technologies for specific purposes.

CHAPTER TWO

WHY COLLECT RIDERSHIP DATA?

There can be many reasons to collect ridership data, and many uses for the data collected. Ridership is an accepted measure of success for any transit agency, and so systemwide ridership totals are usually summarized for senior management and finance departments. Route-level ridership is also of general interest. Service planning and scheduling departments require more detailed ridership data at the trip, route segment, time of day, and/or stop level to be able to match service to demand. Time-related data are often collected in conjunction with ridership data and used to monitor schedule adherence. Analysis of origin-destination patterns generally requires special on-board surveys that go beyond the simple counting of passengers.

This chapter addresses the general purposes for which ridership data are collected and used, and reports purposes and uses at the system, route, trip, and segment or stop levels of data. Specific uses of data are summarized from the survey results. Also included are the departments within each transit agency that use each level of ridership data.

DEFINITION OF RIDERSHIP

The transit industry uses two definitions of ridership. *Unlinked trips* refers to total boardings, and is nearly always the unit of ridership counted in the field. *Linked trips* is the term used to define total riders, and measures the actual number of complete trips from origin to destination, including transfers. The Federal Transit Administration's National Transit Data Base (formerly known as Section 15) reporting requirements specify unlinked trips as the unit for measuring ridership.

Surveyed agencies were split among those that use and report only unlinked trips (19 respondents) and those that report both linked and unlinked trips (14 respondents). No agency reports only linked trips. Among those counting and reporting both linked and unlinked trips, there was a fairly uniform distribution of purposes. Unlinked trips are seen as a measure of transit utilization (at the system, route, or subroute level), while linked trips are used to measure revenue passengers. The ratio of unlinked to linked trips indicates the relative usage of transfers for the transit system. Data on linked trips are generally used only at the system level, while those for unlinked trips are used at all levels.

USES OF RIDERSHIP DATA

System-Level Uses

In the survey, transit agencies were asked to report all purposes for which ridership data are collected and used. Table 1 summarizes the responses from the 33 agencies and indicates that most agencies in the sample count passengers for a variety of purposes. The most common purposes were reported by at least 80 percent of the agencies in the sample. At the system level, 28 agencies (85 percent) collect ridership data to track systemwide ridership totals. The other system-level purpose included in Table 1, to analyze origin-destination patterns, was reported by only 12 systems (36 percent). Other system-level purposes include meeting federal reporting requirements, checking operator compliance with farebox procedures, and counting boardings by fare type.

TABLE 1
PURPOSE OF PASSENGER COUNTING

Purposes	Number of Systems
Compile ridership by route	32
Compile ridership by trip	30
Track systemwide ridership totals	28
Compile boardings/alightings by stop	28
Monitor passenger loads at maximum load points	28
Compile ridership by day type and time period	27
Compile ridership by route segment	26
Monitor schedule adherence	24
Analyze origin-destination patterns	12
Other	6

Agencies using more than one technique for collecting ridership data were asked to indicate the purposes for which each technique is used. The responses to this question are summarized by technique in the next chapter.

The survey also asked agencies for specific uses of ridership data. As shown in Table 2, there was little differentiation in uses among agencies, with each use indicated by over 75 percent of all respondents. At the system level, assessing changes in ridership is a key use of ridership data.

TABLE 2
USES OF RIDERSHIP DATA

Uses	Number of Systems
Assess changes in ridership	32
Add or delete trips	31
Revise (change, continue or add) routes	31
Calculate performance measures	30
Adjust running times	27
Determine locations for bus shelters	26
Other	10

The organizational units most frequently using system-level data include budget and finance (which uses only system-level data in almost all agencies), planning, and scheduling. Over 90 percent of agencies reported that budget and finance

TABLE 3
NUMBER OF SYSTEMS USING RIDERSHIP DATA BY LEVEL OF DATA AND ORGANIZATIONAL UNIT

Organizational Unit	System Level	Route Level	Trip Level	Route Segment Level	Bus Stop Level
Budget/Finance	30	5	0	0	0
Planning	25	31	30	27	25
Scheduling	10	28	30	26	20
Computer Services/MIS	1	1	0	0	2
Operations	2	3	3	2	5
Marketing/Public Affairs	6	5	0	0	2
Research/Analysis/Customer Service	4	3	3	3	4
Senior Management	4	3	0	0	0
Other	1	0	1	0	1

used system-level data. Table 3 shows use of ridership data by level of data and by organizational unit.

Route-Level Uses

Compiling ridership by route is cited by 97 percent of agencies as one purpose for counting passengers. Several other purposes listed in Table 1 are frequently carried out at the route level, including monitoring passenger loads at maximum load points (85 percent), compiling ridership by day type and time period (82 percent), and monitoring schedule adherence (73 percent). Performance measures are frequently calculated at the route level, and running time adjustments, route revisions, and ridership trends also rely on route-level data.

The primary users of route-level data are the planning and scheduling units within an agency.

Trip-Level Users

Over 90 percent of respondents indicate that compiling ridership by trip is one purpose of passenger counting. Varying techniques are used to count ridership at the trip level. Trip-level analysis is frequently carried out with regard to schedule adherence and passenger loads.

Data at the trip level are used to add or delete trips and to adjust running times. As with route-level data, the planning and scheduling units are the primary users of trip-level data.

Stop/Segment-Level Uses

Compiling boardings and alightings by stop is reported as a data collection purpose by 85 percent of all respondents, while compiling ridership by route segment is routinely carried out by 79 percent of responding agencies. Stop-level data is very useful in determining locations for bus shelters. Segment-level analysis is typically used in adjusting running times, but is also used in service planning at some agencies as a more refined method of assessing route performance and needs by route segment.

Farebox-derived data are generally difficult to use at subroute levels, such as for route segments or stops. Route segment data are used almost exclusively by planning and scheduling units or other organizational units involved in detailed service planning analysis. Stop-level data are used more broadly, in large part due to the usefulness of this level of data in making decisions regarding the placement of bus shelters.

SUMMARY

Why collect ridership data? The foregoing discussion suggests four answers:

- To report to external funding and oversight agencies (e.g., federal, state, and local governments; regional authorities; metropolitan planning organizations);
- To monitor trends over time;
- To analyze usage and performance at various levels with the overall goal of enhancing efficiency and effectiveness;
- To identify locations with the greatest boarding and alighting activity, often in relation to the provision of passenger amenities.

As a general rule (and there are many exceptions), smaller transit agencies in stable environments tend to collect and utilize ridership data at the macro levels (system and route) that can often be collected through the farebox. As systems grow larger and more complex, and as operating budgets tighten, agencies have a greater interest in micro-level data (route by time of day, segment, and stop) that may require a range of collection technologies and procedures, but that in turn permit a finer level of analysis and greater technical support for targeted recommendations for change. Perhaps the key factor in determining the level of detail at which ridership data are collected and analyzed is the agency's proactiveness in making minor and major changes to its system.

CHAPTER THREE

PASSENGER COUNTING TECHNOLOGIES AND PROCEDURES

This chapter summarizes the current state of the practice in counting transit riders. General methodological issues, such as the frequency of ridership counts at the system, route, and subroute levels and the use of sampling versus one hundred percent counts, are addressed first. The chapter then summarizes the extent of usage of three different procedures (manual, electronic fare collection, and APC) to count ridership. Capabilities, strengths, and weaknesses of each technology, as noted by users, are reported, and current plans for adopting new passenger counting technologies are indicated. The survey of transit agencies is the primary source of data used in this chapter. Case study findings are included as appropriate.

FREQUENCY OF RIDERSHIP COUNTS

Different types of data are required for different reporting periods. For example, systemwide ridership data may be reported monthly, while trip-level data may be needed for each service change. The survey asked agencies how often they counted and summarized ridership at various levels. System-level ridership is counted on a regular and frequent basis, with over 50 percent of the agencies reporting daily counts and 33 percent reporting monthly counts. At the route level, 48 percent of agencies count and summarize ridership on a daily or monthly basis, and 24 percent count ridership each service change (typically three or four times per year). The majority of systems count ridership below the route level infrequently or only as needed. Table 4 summarizes survey responses.

The service change interval of counting ridership is interesting from the service planning perspective, because this is the most frequent interval feasible for analyzing ridership data at the route and subroute levels. Approximately one-quarter to one-third of respondents report this interval for route and trip-level ridership and for ridership at maximum load points. Of these respondents who count riders at service change intervals, approximately 70 percent are using or testing APC equipment.

The survey also asked agencies how often ridership on any given route was counted and analyzed for service planning or schedule purposes. Half of the systems responding report that weekday ridership is counted at intervals of one year or greater, although 27 percent count weekday ridership at each service change interval. Saturday and Sunday counts occur less often, with approximately 30 percent of agencies counting weekend ridership only on an as-needed basis.

ONE HUNDRED PERCENT VERSUS SAMPLE COUNTS

The standard approach to counting passengers has been to conduct a 100 percent count within a relatively short timeframe (e.g., 4 to 6 weeks) on any given route. Some agencies will use a sample of trips for ridership counts. At more aggregate levels (system and route), agencies with electronic registering fareboxes often estimate ridership by factoring total revenue.

At the system level, 48 percent of the agencies in our sample report factoring ridership from revenue totals, while 42 percent conduct complete counts, usually by tracking all ERF-recorded boardings. At all other levels (route, trip, route segment, and stop), the majority of agencies conduct 100 percent counts, although about one-third of all agencies report the use of samples for counting ridership by trip, route segment, and stop.

Agencies use a variety of factoring and sampling techniques. While no one technique emerged as typical, a common approach is to stratify revenue totals by fare payment category and use average fares for each category to calculate ridership. Another method used by agencies with APC is to rotate APC buses throughout the system in order to sample every trip a certain number of times over a given timeframe.

PASSENGER COUNTING TECHNOLOGIES AND PROCEDURES

Table 5 presents survey results related to how passengers are counted by the various transit agencies. These results are

TABLE 4
FREQUENCY OF RIDERSHIP COUNTS BY LEVEL OF DATA

Level of Data	Daily	Monthly	At Service Changes	As Needed/Other
System	17	11	0	3
Route	9	7	8	9
Trip	3	1	8	21
Route Segment	0	1	3	25
Stop Boardings and Alightings	0	1	3	27
Maximum Load Points	1	1	11	18

TABLE 5
USE OF PASSENGER COUNTING TECHNOLOGIES AND PROCEDURES

Technology/Procedure	Number of Systems Total	Large	Medium	Small
Checkers, Pencil and Paper	23	8	11	4
Electronic Registering Fareboxes	23	6	11	6
On-Board Surveys	15	2	11	2
Vehicle Operator Trip Cards	14	3	9	2
Estimate from Passenger Revenue	13	5	8	0
Checkers and Hand-Held Units	13	3	7	3
APC in Use	8	2	5	1
APC Testing	5	1	3	1
Smart Cards	2	0	1	1
Number of Systems	33	9	17	7

Note: Large systems operate over 1,000 buses; medium systems operate between 250 and 1,000 buses; small systems operate under 250 buses

TABLE 6
PASSENGER COUNTING TECHNOLOGIES AND PROCEDURES BY PURPOSE OF COUNT

Purposes	Checkers Pencil & Paper	Electronic Registering Fareboxes	On-Board Surveys	Estimate from Revenue	Operator Trip Cards	Checkers Hand-Held Units	APC	Smart Cards
All General Purposes	13	3	0	1	3	7	5	0
System Level Ridership	0	16	1	7	1	0	1	0
Route Level Ridership	0	8	0	0	2	2	2	0
Trip Level Ridership	1	3	0	0	1	1	1	0
Loads	0	0	1	0	0	1	0	0
Schedule Adherence	0	0	1	0	0	1	0	0
Special Purposes Only	6	0	1	1	5	1	0	1
Unspecified/Other	5	2	6	3	1	3	0	0
Rider Profile/Market Research	0	0	4	0	0	0	0	0
Ridership by Fare Type	0	2	2	0	0	0	0	0
Currently Testing	0	0	0	0	0	0	5	1

also broken down by system size. Most agencies use more than one method. More than two-thirds of the agencies in the sample report using paper and pencil, and a similar percentage use fareboxes. Thirteen systems use hand-held units in conjunction with their manual checking force. Eight systems are using APCs, while five other agencies were testing APCs at the time of the survey (one test agency has since decided not to adopt APC technology at this time). Two agencies report use of smart cards. Thus, the level of interest shown in advanced passenger counting technologies has not yet translated into widespread use.

From the perspective of system size, large systems (over 1,000 buses) are more likely to rely on manual procedures, particularly checkers using pencil and paper. This may be due to the complexity of the larger systems, a greater need to track ridership by route, or a tendency toward greater specialization at larger agencies that makes it more likely for a separate passenger counting responsibility to have developed before technological advances. Small systems (under 250 buses), on the other hand, are more likely to use ERFs to track passenger activity. Adoption of advanced technologies such as APCs or smart cards is evenly distributed (on a proportional basis) across systems of different size among the agencies in the study sample.

It is interesting to note that three of the five Canadian agencies, but only five of the 27 U.S. transit agencies, use APCs. On the other hand, none of the Canadian agencies surveyed use electronic registering fareboxes. Possible reasons for this discrepancy include Section 15 reporting requirements in the United States and differences in the number of prepaid boardings between agencies in the two countries.

Table 6 provides a breakdown of passenger counting procedures by count purpose and lends additional insight into why agencies choose certain methods. For example, manual counts with pencil and paper tend to be used for general purposes or (in cases where other procedures are preferred) for special purposes. Estimating ridership from revenue and using electronic farebox data are both most common for system-level data. On-board surveys have specialized applications, while hand-held units and APCs are used for general purposes. It should be noted that the category "All General Purposes" in Table 6 includes the most common purposes, i.e., system, route, and trip level ridership; passenger loading; and schedule adherence. This category is included to show the widespread usefulness of certain technologies and procedures. A cursory glance at Table 6 might suggest that no agencies use APCs to track passenger loads or use paper and pencil to count route level ridership, but these purposes are included in the general purposes category. Thus, in reading the table the reader must keep in mind the inclusive nature of the "All General Purposes" category.

Each of the following sections of this chapter focuses on a specific category of passenger counting technology (manual, electronic registering farebox, smart card, and APC). Survey responses from agencies currently using or testing these various technologies are summarized. The usefulness of a particular technique varies, depending on the level of ridership data sought. Non-manual techniques are rated in terms of usefulness and satisfaction. Respondents listed benefits associated with each technique and offered advice for other agencies considering the specific technology. Problems encountered with all methods of counting riders are presented as well. The final section compares user responses across the different categories of technologies and procedures.

Manual Technologies and Procedures

Virtually every agency responding to the survey uses manual data collection for some purpose, even if it is not the primary data collection technology. Manual procedures are often the base against which other technologies are compared. The following procedures are included in this category:

- Estimating ridership from passenger revenue
- Using vehicle operator trip cards
- Using traffic checkers, pencil and paper
- Using traffic checkers and hand-held units
- Distributing on-board surveys.

Estimating ridership from passenger revenue could also be categorized under electronic registering fareboxes, but historically has been done on the basis of manual revenue counts without ERFs.

Twenty-three systems answered questions in this portion of the survey. Those agencies that make only occasional use of manual passenger counting procedures did not respond and thus are not included in this summary. The comments and responses for manual data collection technologies and procedures thus are indicative of those systems that rely on these tools for collecting ridership data.

Manual data collection is rated as most useful at more disaggregate levels (i.e., route segment, stop and trip levels). Manual techniques are moderately useful for collecting route-level data, but are not particularly well-suited for gathering system-level information.

A key benefit of manual passenger counting is that it is a well-established method that does not require special technological knowledge or extensive capital expenditures. Manual counting is not controversial and does not generally require a re-thinking of how data are organized and analyzed within an agency. The use of hand-held units is a partial exception. Agencies with hand-held units have reorganized the data input function, and in some cases the increased availability and timeliness of detailed ridership data have affected analytical techniques and procedures.

Major problems encountered with manual collection techniques fall into four main categories:

- Accuracy and consistency of the data
- Labor intensiveness of manual techniques
- Reliability of the traffic checkers
- Cost and consequent limitations on data collection resources.

Accuracy is a major concern in any data collection effort. The use of manual techniques can result in errors at the initial collection level (i.e., by the traffic checkers), and these errors tend to be random in nature. Transcription of manually collected data in the data input stage is a second source of error. Agencies invest time in training personnel, but a "burnout" factor among traffic checkers that affects reliability of data has been noted and requires consistent supervision. Hand-held units (which include units manufactured specifically for data collection, laptop computers, and palmtop computers) eliminate data transcription, but introduce programming and operational complexities.

Manual passenger counting is a very labor-intensive and time-consuming activity. The traffic checkers who ride the buses or conduct point checks at key locations form a large portion of the labor required, but professional staff time must also be invested in preparing assignments, checking for accuracy, and supervising the checkers. In some agencies, work rule restrictions affect the efficient assignment of traffic checkers. The process of editing and cleaning the data to ensure accuracy and entering the data into a computerized format can constitute a major share of the time involved in the overall passenger counting process. All of these factors reduce the frequency of route checks, the productivity of professional staff, and the timeliness of the collected and processed data. Shortage of qualified personnel is reported as a factor contributing to these problems.

Reliability of the checkers affects the first two problems discussed in relation to manual passenger counting procedures. Absenteeism is a recurring problem. Fitting assignment make-ups into an established schedule is not always possible, resulting in missed data and a less than 100 percent ridecheck.

The limited resources available, both in personnel and fiscal terms, hinders effective manual data collection efforts. Many agencies that rely on manual data collection have seen their traffic checker forces reduced in number as budgets have tightened in the past several years. A contributing factor is the frequency of high-level requests for special checks that disrupt the established data collection schedule. A successful manual data collection program is not cheap to operate. Controlling costs while maintaining the required quantity and accuracy of data is a major challenge.

Beyond these considerations, however, several agencies that count passengers manually are very satisfied with the results and do not see clear benefits for themselves from proposed moves to new technologies that permit more frequent data collection. Many agencies have established schedules for periodic analysis and evaluation of routes that adequately meet the transit agency's needs. Some concern has been expressed regarding the ability of agencies to make use of additional ridership data, given limited resources and staff.

This does not mean that there is no interest in other data collection technologies among agencies that currently collect ridership data manually. Only one agency indicated that there has been no consideration of other technologies. Hand-held units and APC systems were most frequently mentioned as having been considered, and half of all respondents in this area indicated an interest in electronic fare collection (fareboxes and/or smart cards). Roughly 40 percent of agencies have rejected at least one passenger counting technology. Reasons for rejection include cost, reliability, practicality, and selection or testing of other options.

Approximately 50 percent of systems in the manual category are planning to purchase new passenger counting technologies, primarily APC units. At nine agencies, investment in new technologies is still being decided, although certain options may have been rejected already. Agencies express a strong interest in obtaining additional information regarding vendors, current users and their experiences, availability, software interfaces, and vendor support. The ability to duplicate and improve on current data collection activities is also of interest.

In summary, 70 percent of agencies responding to the survey are still collecting at least a significant portion of their ridership data manually. Manual techniques are seen as very useful at more disaggregate levels of data collection, and as well-established and relatively straightforward. Areas of concern include data accuracy, labor intensiveness, reliability of traffic checkers, and limited resources. Most agencies have at least considered other passenger counting technologies, and 50 percent plan to make the investment. Information regarding vendors, available technologies, and experiences of other transit agencies is reported to be of greatest use to transit agencies.

Electronic Registering Fareboxes

Electronic registering fareboxes (ERFs) are much more commonplace in the United States, than in Canada. A total of 23 agencies (all in the United States) completed this section of the survey. GFI and Cubic are the predominant manufacturers of fareboxes used by agencies in this sample, with well over half (17 of 20 specifying a particular manufacturer) using GFI fareboxes. Revenue issues and related concerns (including revenue control and accountability) played a much larger role than collection of ridership data in the decision to purchase ERFs, but agencies have utilized the ability to count passengers with this technology.

Ridership data are accumulated in a variety of ways; the most common are by bus block or run assignment and by operator run assignment with route and trip segmentation. The accuracy of farebox data is most commonly verified by a comparison with revenue or with manual counts. Pass boardings can be problematic because they require operator intervention to be recorded.

As with the introduction of any new technology, a "debugging" period occurs in which employees become familiar with the new equipment and start-up problems are addressed. The average length of the debugging period for ERFs is just under 18 months, with a range from 6 weeks to 6 years. Several agencies report an ongoing need to train new operators and to work out problems related to changes in fare media. One agency has had considerable success by including preprinted trip numbers and fare categories on the operator paddles.

The usefulness of ERFs is greatest at aggregate levels of data collection. Respondents rated ERFs very highly for collecting system-level data, and above average for route-level data. Fareboxes are least useful at the stop or route segment level, and were rated below average at the trip level.

On average, agencies with ERFs are satisfied with the performance of this equipment in terms of counting passengers. Six agencies expressed some dissatisfaction, but there was no "very dissatisfied" response.

Primary benefits of ERFs include the collection of greater quantities of data at greater levels of detail. The ability to count ridership by route, trip, block, and fare category was mentioned repeatedly by transit agencies, who also noted improved accuracy and reliability as well as better access to data. Information regarding boardings by fare category is often of interest to marketing personnel. Improvements in accountability and revenue control are also seen as important benefits.

Problems encountered with ERFs include the following:

- Mechanical/equipment problems
- Operator compliance
- Software problems
- Accuracy of ridership data.

Mechanical problems include currency jams, aging coin mechanisms, difficulty reading swipe cards, overloaded vaults, and reliability of the time/date stamp that records when trips were made. Agencies reported that some of these difficulties were solved to a great extent over time (more frequent cleaning of the heads on swipe card readers was a notable example), while others such as currency jams appeared to be chronic problems. Mechanical problems are not directly related to collection of ridership data, but are a source of concern to the agencies.

Bus operator compliance and attitudes are key issues in ensuring the usefulness of farebox data. Operators must enter specific codes at the beginning of their shifts and at the start of each new trip to tie fares to specific blocks and trips. Operators also need to record non-cash boardings using specific keys on the keypad. These additional operator duties frequently must be agreed to in negotiation with their union representatives. Lack of compliance can render much of the data useless. A contributing factor is that problems with operator compliance are non-random, i.e., data on specific trips driven by specific operators are consistently missing or inaccurate. One transit property noted that the first operator to take a bus out in the morning generally enters correct data, but that the level of compliance declines with subsequent reliefs. At another agency, Route 0 often has the highest ridership on daily printouts of ERF data.

Mechanical difficulties and operator compliance were most frequently cited as problem areas with ERFs. Software problems primarily concerned limited data manipulation capabilities and difficulties with information retrieval and reports at the route level. Accuracy issues, related to operator compliance and software issues, were raised as a problem (although several agencies also cited increased accuracy as a benefit of ERFs). Incomplete data and trip-by-trip inconsistencies in ridership counts contributed to concerns over accuracy, and the verification of ridership data was also problematic.

Comprehensive, ongoing training for bus operators is critical in terms of maximizing the benefits of ERFs. The agencies that have been most successful are those that have developed internal programs to access and analyze ridership data. Complex fare structures can limit the effectiveness of ERFs in counting passengers. Specific responsibilities and policies for collecting and analyzing data should be established prior to implementation. One policy should be to test frequently for accuracy.

In summary, electronic registering fareboxes receive high marks for obtaining aggregate-level (system or route) ridership data, although they are not the appropriate technology to collect detailed ridership information. Operators can make or break ERF data collection efforts. There is a consequent need for comprehensive and continuous training, particularly when new fare media are introduced. Processing of ERF-generated data is a key issue that can be overlooked during implementation. Effective software, establishment of clear responsibilities and policies, and ongoing tests for accuracy enhance the usefulness of ERFs.

Smart Cards

The use of smart cards by transit agencies is still at the demonstration or early implementation stage, and so there is little information to report at this time. Only three agencies (South Coast Area Transit, Seattle Metro, and Pierce Transit) responding to the survey reported even limited experience in demonstration projects regarding the use of smart cards on buses, although MARTA in Atlanta began use of a bank card as a smart card on its rail system in conjunction with the 1996 Summer Olympics. Preliminary findings, with the emphasis on "preliminary," related to smart cards are summarized in the following paragraphs.

Agencies that have tested smart cards are very positive about their experiences and the potential of this technology. Of course, the benefits of smart cards are not primarily in the area of passenger counting, but they do offer the ability to obtain stop data for riders using smart cards as their fare payment method. Problems identified in demonstration projects to date include a lack of integration with the farebox and other onboard equipment and software, software bugs, data retrieval (particularly the need for training), and hardware problems. Agencies contemplating smart cards should be very deliberate in system design and (in the words of personnel at one demonstration site) "Don't believe anyone who tells you that it's simple." The time commitment for training personnel in retrieving and formatting data, and in performing these functions, can be extensive. Maintenance Department's support for installation and maintenance of additional equipment strongly influences the transition to smart cards. To gain their support, operators also need to be informed of the value of smart cards. Agencies without ERFs would require operator intervention to record cash fares in a smart card system, and experience at demonstration sites shows that operators are the ones who must deal with passenger complaints regarding smart card malfunctions.

In general, passenger counting is not expected to be a major factor in the decision to use smart cards. As is the case with ERFs, adoption of this technology will be driven by other factors, but there will be ancillary benefits in terms of collecting ridership data. The demonstration projects conducted to date suggest that smart card penetration among transit users will need to be much greater to provide any meaningful ridership data beyond how many people are using smart cards.

Automatic Passenger Counting

APC units have the ability to count passengers as they board and alight a bus as well as to record times at each stop, and thus can provide disaggregate data well suited for service planning and scheduling purposes. Thirteen agencies (three in Canada, 10 in the United States) report using APCs. Eight of these agencies can be classified as regular APC users, while five others were in the demonstration phase at the time of the survey.

APC units are not needed on every bus in the fleet. The eight agencies that make regular use of APCs equip about 10 percent of their fleet with APC units, and rotate this segment of the fleet throughout the routes in the system. Demonstration agencies typically equip two percent of their fleet, although one of the smaller agencies was able to equip 20 percent of its fleet with APC units.

APCs count passengers in two different ways. Infrared beams are used in seven systems included in the study sample. These beams cross the stairwells at waist-high level. As passengers board and alight, the beams are broken (in a different order for boardings and alightings), and passenger activity is recorded *(8).* Treadle mats are used in six systems included in the study sample. The mats are mounted to the vehicle steps and contain switches that close when the mat is stepped on. The transitions of closing and opening switches and the times between them determine passenger flows (6). In certain climates, treadle mats can be difficult to maintain, but most observers report no difference in accuracy between the two technologies.

A means of ascertaining location is required, so that the boardings and alightings can be matched to a particular stop. Six of the 13 APC systems are signpost-based. The signposts calibrate location along a route, and the mileage before or after the signpost is used to locate the particular stop. Five agencies use some sort of global positioning system (GPS) that locates the bus via satellite. One agency reports having used both methods, and one of the demonstration agencies relied on bus mileage to locate the vehicles. Signpost and GPS systems both have their advocates. There appears to be a trend toward GPS among transit agencies recently purchasing or considering the purchase of an APC system.

Tri-County Metropolitan Transportation District of Oregon (Tri-Met) in Portland is one of the case study agencies discussed in detail in chapter 7. Tri-Met is in the process of switching its APCs from signposts to GPS, and reports that the integration of APC with the new automatic vehicle location (AVL) system being installed in the buses results in much lower unit costs for the APCs, because the vehicle location component is no longer needed within the APC unit. Locational referencing problems are more common on systems without AVL.

The break-in or debugging period for APCs averages 17 months, very similar to the average for electronic fareboxes. It is possible that any new passenger counting technology would have a similar period of adjustment.

APC equipment is most useful in collecting ridership data at the trip level, although it received above average scores at all but the system level. Stop-level scores were slightly lower than other disaggregate scores, suggesting some concerns with correct stop identification. Of the technologies that were rated for usefulness, APCs scored highest at the route and trip levels.

Agencies using APCs are satisfied with their performance. Four agencies reported that they were "very satisfied" with APCs.

The satisfaction levels are closely tied to the benefits experienced by agencies who use or are testing APC units. Seventy percent of respondents cite the ability to collect a greater amount of data at more detailed levels with greater frequency. Detailed data collection is particularly valued by planning and scheduling departments. Cost savings are also mentioned by 30 percent of the agencies.

APCs do have problems, and the most common is software-related. Software appears to be the limiting factor in making use of APC capabilities. The increase in data flow often requires development or upgrading of analytical programs, and data processing can be time-consuming. In the other direction, APCs require consistent maintenance by the agency of data bases containing schedule and bus stop information, including stop patterns and variations by trip, for each route.

Next to software, hardware problems were reported most often, including equipment failure, maintenance problems, and the durability of APC units on the buses. For signpost-based systems, signpost detection and difficulty in coordinating signposts with bus route assignments are concerns.

Acceptance of APCs throughout the agency is a final area of concern. APC buses do not always have priority in maintenance, and dispatching personnel are not always pleased at having to assign specific buses to particular blocks or runs. APCs can require a change in operating procedures to be used effectively. In chapter 7, Tri-Met and OC Transpo report on the process of reaching agreement with operations on assigning APC buses. APC-equipped buses are often put in a separate row or place at the depot so that operators can access them without having to move other buses. OC Transpo also adopted a policy of not using APC information to take disciplinary action against an operator, thus enhancing operator cooperation.

The survey included a question on the proportion of raw data collected by APCs that is converted into data used for service planning and scheduling. The overall average is 75 percent, but several respondents cautioned that the number requires explanation. There is some tension between agencies that feel they are being oversold on the benefits of APCs or other technology enhancements and other agencies and technology suppliers that view the expectations of new technologies on the part of potential users as unrealistic. Most agencies with APC systems appear to be satisfied with the amount of usable data they collect.

Agencies considering APCs were strongly encouraged to talk with or visit agencies using APCs and to research what is available. Agencies also need to evaluate the adequacy of their system database and reporting capabilities before implementing an APC system. A strong commitment from management is seen as critical in embarking on a changeover to APC. Management commitment is very useful in enlisting the cooperation of operations and maintenance departments.

SUMMARY

Transit agencies use a variety of means to count passengers, depending on the need for detail and the purposes of the count. System-level counts are appropriate for monitoring trends in usage and for reporting overall ridership. Service planning and scheduling need data at a finer level of detail in order to match service to demand. Many agencies continue to rely on tried-and-true methods of manual passenger counting. The pattern of technology adoption differs in the United States and Canada, with stateside systems relying on electronic registering fareboxes while Canadian systems are more likely to employ APC units to count passengers. Smart cards are the latest technological development, but have not progressed beyond the demonstration/early start-up stage. Agencies appear eager to learn more about APCs and smart cards but are generally cautious when it comes to new technologies. The prevailing attitude was summed up by the respondent who expressed a strong willingness to be the second agency to implement new technologies.

Table 7 summarizes average agency ratings of the usefulness of different passenger counting techniques for various levels of data collection. The scale is from 1 to 5, with 1 being least useful and 5 being most useful. Electronic fareboxes score highest in terms of usefulness at the system level. At the route and trip levels, APCs receive the best scores, while manual techniques are rated as slightly more useful than APCs at the route segment and stop levels. Responses related to smart cards were insufficient to include in the tables.

TABLE 7
USEFULNESS OF PASSENGER COUNTING TECHNOLOGIES AND PROCEDURES

Data Collection Level	Manual Techniques	Electronic Registering Fareboxes	APC
System Level	2.05	4.33	2.82
Route Level	3.63	3.81	4.37
Trip Level	4.21	2.60	4.64
Route Segment	4.44	1.06	4.27
Stop	4.21	1.00	4.09

Scale: 1 = Least Useful, 5 = Most Useful
n: 19 systems for Manual, 20 for ERF, 11 for APC

CHAPTER FOUR

PROCESSING AND REPORTING

This chapter addresses post-counting issues related to data input, validation, and reports. These areas are not a primary focus of the synthesis, but must be included in any discussion of passenger counting techniques because the processing and reporting of data affect their usefulness for the agency involved.

DATA INPUT

Automated input of ridership data is one area in which hand-held units, ERFs, and APCs have a clear advantage over manual techniques. Even agencies that have established successful manually based data collection programs are very interested in automating the data input function. Nearly all of the agencies that count riders manually also use a manual process in which completed checker forms are given to clerical personnel to input into the computer. Toronto Transit Commission relies exclusively on an optical character reader (OCR) for data input, with few other agencies testing OCR technology.

Agencies that collect ridership data using hand-held units are evenly split with regard to data input procedures. Slightly over half of the agencies transmit data via a physical connection, while slightly under half have established remote data transmission capabilities (usually via a modem). With remote data transmission, the checkers can also get their next assignments via modem, and thus are not required to report to the office. This is sometimes viewed as a benefit, and sometimes as a disadvantage.

For electronic registering fareboxes, a probe of the farebox at the garage is by far the most common means of transferring data to the host computer. Five systems report retrieval of data at the garage without a physical connection (including one system that retrieves smart card data), and two report dynamic or periodic remote retrieval of farebox data.

Of the eight systems using APCs, half retrieve the APC data at the garage without a physical connection. The others either establish a direct downlink at the garage or transmit data remotely via radio while the bus is on the street. All three of these techniques are used by at least one of the five systems testing APCs. Automated data input is frequently cited as a major benefit of technology-based options for counting ridership.

Automated procedures are seen as eliminating a source of error as well as a major bottleneck in the overall process of collecting and analyzing ridership data. The decrease in turnaround time cited for various data collection technologies is closely related to automated data input.

DATA VALIDATION

Validating ridership data is important to ensure data quality, but can be difficult because of normal day-to-day variations as well as seasonal or weekly effects (for example, many agencies report that ridership is greater on the first few days of the month than at the end of the month). Data validation can take place at the route, time-of-day, or trip level. Few if any agencies rely on a single means of validation. The most common step cited is to compare with previous counts to establish that the order of magnitude is correct. Agencies often rely on the professional judgment of planners, schedulers, and others responsible for the route to determine the validity of ridership data. Experienced transit personnel can very quickly sense problems with ridership data. Other validation techniques include a comparison of ridership and revenue totals and examination of trip-level data to see if there are unexplained variations across trips.

Agencies take a variety of approaches to the issue of data validation. One approach is to check ridership for reasonableness in terms of order of magnitude. This approach does not involve detailed scrutiny under the assumption that small errors tend to cancel out. There is also a sense that small differences in ridership or average loads will not affect service planning and scheduling decisions regarding a particular route. A second approach is to analyze trip-by-trip ridership counts in detail to determine accuracy, and to make adjustments where necessary. Practitioners of this approach argue that ridership data are frequently used to answer future unanticipated questions and thus need to be as accurate as possible. There are also agencies that do not have the personnel available to conduct anything more than very cursory checks of ridership data. Some agencies take a random sample of trips and analyze these in detail to gauge overall accuracy and to identify problems in this area. There are likely to be other approaches not revealed by this sample of transit agencies. The ultimate use of ridership data and the availability of resources to devote to data validation are major considerations in determining the approach taken.

Automated data input procedures often include a validation component based on thresholds. Trips that fall outside established thresholds are flagged for manual inspection and editing. Some automated programs search for errors such as mismatches in total boardings and alightings on a trip or negative loads at any point on a trip, and may contain algorithms for making minor corrections without manual intervention and/or for discarding data with unexplained discrepancies. An immense amount of effort is needed to validate ridership data at the trip level, making automated validation components extremely useful.

DATA REPORTS

Transit agencies generate a variety of reports based on the ridership data as well as on other information gathered concurrently. Reports on system-level ridership are typically generated from ERF data or derived from revenue extrapolation and are most commonly prepared on a monthly basis. Route-level ridership reports use both ERF and boarding/alighting data and are typically prepared monthly or quarterly. Performance reports also use both ERF and boarding/alighting data and are prepared monthly, quarterly, or annually. Reports at the route segment level are not usually scheduled but are prepared as needed. Stop-level data are summarized and reported annually at some agencies, although it is more common to prepare stop-level reports on an as needed basis. Schedule adherence reports were cited least often among the six categories specified here and on the survey, but are still prepared by a majority of responding agencies. No particular pattern emerged with regard to the timing and frequency of schedule adherence reports.

The majority of agencies developed data processing and report generation software using in-house programming expertise, usually (but not always) in the MIS or computer services department. Those agencies that developed processing and reporting software through an outside vendor reported considerable customization or modification of the software. In many cases, regardless of the original source of the software, ongoing modification appears to be the rule rather than the exception.

The ability to query the ridership database becomes increasingly important as data users increase their understanding of the system and begin to ask new types of questions. The majority of agencies have built a query component into their ridership database. Some prefer to have the end users query the database directly, while other agencies have a database manager who handles all special requests.

SUMMARY

Processing and reporting procedures, while not directly related to the topic of this synthesis, are important in terms of enhancing the usefulness of ridership data within a transit agency. Automated data input technologies increase accuracy and decrease turnaround time for processing data. Agencies take several approaches to the verification of ridership data, usually involving a cross-check either to previous counts or to counts done by other means. Aggregate-level data tend to be reported more frequently and regularly, but the ability to query the ridership database on an ad hoc basis gives the planners and schedulers, who usually have the greatest need for detailed data, access at any time.

CHAPTER FIVE

ORGANIZATION AND RESOURCE REQUIREMENTS

Organizational issues have a potentially strong effect on the success of ridership data collection, particularly in cases where new technologies are being introduced. More complex passenger counting technologies and procedures necessarily involve a broader segment of the transit agency. This chapter examines organizational responsibilities for the collection of ridership data. In addition, the need for involving different departments, depending on technology, is considered. Staff requirements for implementing a passenger counting program are summarized, along with the cost. It should be noted, however, that costs reported by transit agencies varied, depending on the methods and assumptions used. Some agencies were able to go into great detail regarding operating costs; some appeared to lump costs related to the analysis of ridership data in with broader planning and scheduling functions and did not provide a breakout; other agencies reported no information on certain costs. In the cost discussion, averages, medians, and ranges are used to provide as complete a picture as possible with limited data, but the reader is cautioned that cost data are neither uniform nor complete.

ORGANIZATION

Planning and (to a lesser extent) Scheduling departments are typically responsible for all aspects of ridership data collection, including overall methodology, selection of data to be collected, system set-up and implementation, and day-to-day management. Budget and Finance departments are most likely to take part in decisions regarding overall methodology (due to the cost implications) and day-to-day management. The Computer Services or MIS department is heavily involved in system set-up and implementation. Specialized departments dealing with research, analysis, transit studies, or strategic planning can also have responsibilities in these areas.

Very few agencies cite specific responsibilities assigned to the Operations and Maintenance departments with regard to passenger counting. Experience indicates that these departments have a strong effect on successful implementation of new technologies, particularly APCs and electronic registering fareboxes. Both technologies present unique maintenance problems, and often the Maintenance department is not inclined to assign a particularly high priority to these problems. Operations must ensure that its personnel are trained to use ERFs correctly, and must re-train the operators when changes are made to the fare structure. The dispatch function is critical to ensuring that APC-equipped buses are assigned to routes where ridership data are required. One common theme in the questionnaires and the case studies is that the entire agency must be sold on the purposes and benefits of passenger counting technology. This effort should naturally focus on the departments whose cooperation is essential but whose responsibilities are limited to particular elements of the system.

Almost half of the agencies report that the data users are different from those responsible for the data collection process. The need to clarify responsibilities for various aspects of data collection is one element in avoiding problems that can arise in the separation of functions. Keeping open channels of communication among the various departments involved in aspects of passenger counting is also mentioned.

STAFFING

Survey respondents were asked to estimate the number of staff (in terms of full-time equivalents (FTEs)) assigned to carry out the passenger counting program in five separate categories: managers/professionals; support (maintenance); clerical; traffic checkers; and other. The overall average is 14 FTEs, with a median of seven (indicating that the average is pulled up by a few systems with many employees).

Agencies were then categorized by primary passenger counting technology. Manual and ERF agencies could not be totally separated, because several rely on both techniques. Not surprisingly, agencies with manual procedures had the highest average (17) and median (10.5) number of employees, due primarily to the number of checkers (average = 11; median = 7). The average and median number of employees assigned to carry out the passenger counting program are broken down by type of passenger counting technology in Table 8.

To control for the size of agencies, the results in Table 8 are also presented for large, medium, and small agencies as determined by the number of buses. Within each agency size grouping, the overall pattern of fewer employees associated with advanced technology (in this case, APC) was consistent.

Agencies that changed to a more automated data collection technology were asked if the shift resulted in any headcount reductions or additions. The primary area where reductions took place, not surprisingly, was in the checker force. Six agencies reported an average decrease of 10 checkers and one supervisor with a change in passenger counting procedures. Four agencies reported adding an average of one or two programmers or technicians. A shift to more automated data collection was accompanied by a need to enhance computer and analytical skills.

COST

As noted in the introduction to this section, cost data from the survey are not completely reliable. There is considerable variation across agencies, and not all agencies reported costs

TABLE 8
AVERAGE AND MEDIAN NUMBER OF EMPLOYEES ASSIGNED TO PASSENGER COUNTING BY PASSENGER COUNTING TECHNOLOGY

Technology	Number of Employees							
	Total		Large Agencies		Median Agencies		Small Agencies	
	Average	Median	Average	Median	Average	Median	Average	Median
Manual	17.2	10.5	23.2	23.9	16.4	8.0	2.8	2.8
Hand-held units	17.8	9.0	38.5	38.5	8.5	8.5	6.3	6.3
ERF	15.7	12.0	23.2	23.9	14.6	8.0	1.6	1.6
APC	5.1	4.0	6.5	6.5	5.5	4.0	0.3	0.3
All Systems	13.9	7.0	22.8	22.0	13.0	7.0	3.2	2.8

or provided sufficient detail to categorize specific cost numbers. Some agencies included software or installation costs, while others reported only hardware costs. As one example of the problems in dealing with cost data, MARTA in Atlanta reported a capital cost of $17 million for its ITS system installation, which includes APCs. Median figures are probably more useful for costs than averages, which can be significantly inflated by numbers like $17 million.

With these caveats, reported capital costs are highest for ERF purchases (median = $1.4 million). The median capital cost for APC equipment is approximately $600,000. The difference between the two is accounted for by the fact that fareboxes are needed on every bus, while APC units are generally placed on 10 to 15 percent of the fleet. Capital costs for manual and hand-held techniques are both under $50,000. Software costs can account for 25 to 50 percent of total capital costs for an APC system, according to the two agencies that were able to provide a reliable cost breakdown.

Median reported operating costs are $650,000 annually for agencies using manual/hand-held methods (these agencies are counted together in the operating cost category due to low responses in this question), and $150,000 annually for agencies using ERE Agencies with APC report median operating costs of $90,000, due primarily to decreased labor requirements. Median maintenance costs vary from $14,000 for hand-held and manual methods to $75,000 for APC, and $105,000 for ERF technology per year.

While cost data from the survey responses are fragmentary and not always consistent, the general trends correspond with conventional wisdom. Capital and maintenance costs associated with passenger counting are higher at agencies that have invested in ERF and APC technology, while operating costs are lower at these agencies. Manual techniques are labor-intensive and require lower capital expenditures. Median cost data suggest a short payback period for purchase of an APC system, but these cost estimates are based on incomplete data and do not fully reflect differences among agencies in terms of size and/or labor cost.

Costs can vary significantly for the same type of technology depending on optional items included. Software is often classified as an optional item. Agencies considering purchase of a specific technology for passenger counting should not rely on these figures, which are included in the report for informational purposes to provide comparative estimates, but should contact suppliers or other agencies that have recently made purchases to obtain additional cost information.

SUMMARY

Planning and Scheduling departments generally have primary responsibility for all aspects of ridership data collection. There is a clear need to involve other departments in the process, particularly when an agency is changing to a more automated technology. Staff requirements are highest at agencies with manual data collection, owing to the sizable traffic checker force required, and have been reduced at agencies shifting to more advanced technologies. A change in passenger counting technology can require upgrades in computer and analytical skills. Reported capital costs are greatest for farebox and APC systems. APC agencies report lower annual operating costs and higher maintenance costs. Median cost data suggest a relatively short payback period for investments in passenger counting technologies such as APC.

CHAPTER SIX

TECHNOLOGY PROVIDERS' PERSPECTIVE

This chapter provides a shift in perspective from the transit agencies using various passenger counting technologies to the companies providing the systems. A full review of technical features, capabilities, and performance is well beyond the scope of this synthesis. The intent of this chapter is to provide observations from selected technology providers regarding the experience with applications of technologies at different systems, with particular focus on factors seen as affecting success or failure in the adoption of new passenger counting technologies.

TECHNOLOGY PROVIDERS INTERVIEWED

Information was gathered through telephone interviews with selected technology providers. The selection process for interviewees was based on firms that were cited most frequently as sources of passenger counting systems by transit agencies responding to the survey. These firms provided basic information on their products, and were then interviewed regarding their perspectives on passenger counting technologies within the transit industry. Companies providing information for this chapter include:

- Echelon Industries, Inc., Diamond Bar, California, a consulting firm with specific experience in the design and implementation of APC systems and smart card technology;
- Microtronix Vehicle Technologies, Ltd., London, Ontario, provider of APC systems;
- Red Pine Instruments Ltd., Denbigh, Ontario, an engineering company that manufactures APC hardware;
- Urban Transportation Associates, Cincinnati, Ohio, specializing in the supply of APC hardware, software, and expertise; and
- Wardrop Applied Systems Inc., Mississauga, Ontario, a firm that provides software for turnkey APC systems.

The list of companies is weighted toward APC providers. Attempts were made to contact the major farebox manufacturers (Cubic and GFI) via telephone and/or letter. Neither company responded to requests for an interview.

PERSPECTIVE ON TRANSIT INDUSTRY APPLICATIONS

One problem facing technology vendors is that transit agencies are often not sure what they want from a particular passenger counting technology. The transit industry tends to focus too much on the hardware side and not enough on the need and uses for ridership data within an agency. There is often an erroneous perception that a technological solution will provide 100 percent accuracy. Agencies do not always realize at the outset the need to provide a strong commitment to a new technology and to invest in the upgrade of internal procedures and staff training (in terms of computer and data analysis skills) to make maximum use of whatever passenger counting technology is selected. The internal dynamics of transit agencies play a major role in determining the success of a new passenger counting technology installation.

Technology companies also recognize several key technical issues contributing to success. Variations in bus design can make installation of APC systems more or less difficult. A good vehicle location system is viewed as necessary to optimize APC performance; signpost and GPS-based systems both have their advocates. The choice of treadle mats versus beams as the means of actually counting passengers can be influenced by climate and vehicle design; some companies view one counting technology as superior to the others, but there are again a variety of opinions. The integration of APC systems with other technologies on and off the bus can enhance usefulness, although some agencies are reported as preferring a stand-alone APC system. Diagnostic tests and software algorithms that process boarding and alighting data are key components of an effective APC package. Vendor support is also cited (by vendors) as important.

One concern voiced by transit agencies is the ability to use APCs on low-floor buses. Steps control the speed of access and egress and thus enhance the accuracy of treadle mat systems, while beam systems are not equipped to handle the parallel flows of passengers possible with wide-door low-floor buses. APC technology is constantly evolving, however, and recent tests of APCs on low-floor buses in Montreal (an optical sensor system) and Ottawa (beams installed on an Orion II) have revealed fewer problems and greater accuracy than initially expected. While innovative bus designs can cause problems with the placement of APC equipment, these problems are not unsolvable. The ongoing evolution of APC technology does have the effect of making development of industry standards more difficult.

There are obviously several benefits obtained from particular passenger counting technologies, and these have been discussed by the transit agencies elsewhere in this synthesis. Technology providers working with a variety of agencies have noted that enhanced passenger counting techniques allow an agency to be proactive instead of reactive.

From their experiences, technology providers offer the following observations regarding factors contributing to a successful application of new passenger counting technologies:

- *Commitment of senior management*. Support from the general manager has a ripple effect throughout the agency by raising the priority attached to passenger counting.

- *Active management of the passenger counting system.* Senior management support is critical, but agencies that have successfully adopted new technologies are characterized by a mid-level person who assumes responsibility for the system and takes the necessary action to ensure its proper functioning. This person typically is responsible for ridership data collection and/or use.
- *Ability to utilize ridership data.* New technologies often require increased attention to internal agency databases and analytical techniques.
- *Maintenance.* Prompt maintenance will ensure maximum accuracy. Adherence to APC procedures is also recommended.

The following factors were mentioned as potential pitfalls that can jeopardize a successful APC implementation:

- *No internal changes to accommodate new technology.* A significant investment in time and effort is needed to make the new technology work well by updating databases, ensuring that the system receives the priority it needs, and training staff in its maintenance and usage. In a very real sense, a passenger counting system does not stand alone.
- *Lack of ownership.* Someone within the agency needs to take the responsibility for making the new technology work. Without this, the technology can fall between the bureaucratic cracks. Internal agency politics can lead to the same result.
- *Unnecessary customization.* This phenomenon is related to the emphasis on technology seen within the transit industry. Attempts to redesign what is available on the market to make one's own system unique or better almost always result in failure. Most installations require a fair degree of customization to match agency needs, but there are examples, such as Lane Transit District in Eugene, Oregon, where a good passenger counting system has been established by combining standardized APC modules.

Another concern of technology providers is the high expectations for accuracy using new technologies. Agencies sometimes appear to assume that their manual passenger counting techniques are 100 percent accurate. Under normal conditions, most suppliers indicate that an agency can expect 85 percent accuracy, i.e., 85 percent of all boardings and alightings will be counted correctly. Increases in accuracy are dependent on the quality and timeliness of maintenance diagnosis and response and the volume of inventory of spare parts. Survey results for current APC users reveal that, on average, 75 percent of APC data are usable, and APC agencies indicate that this is still significantly more data than what had been available using previous collection techniques.

Cost is of major interest to agencies considering new passenger counting technologies. As noted in chapter 5, reported costs of new technologies vary considerably. APC technology providers indicate that several factors affect the total cost, including the number of APC units ordered, whether the agency or the vendor installs the system, how location is ascertained (by APC units or by an integrated AVL system), and what optional components (software is frequently in the optional category) are included. Some agencies (Metro in Cincinnati is one example) lease passenger counting equipment for use as needed.

Most of the technology provider interviews took place with companies that are involved with APC systems, but there were also comments related to smart cards. An industry shift toward proximity cards for fare collection has been noted, and there is some concern that this will overshadow the fact that other solutions are appropriate in certain circumstances. Magnetic strip and contact cards can be the best option for a particular agency, and there is also a potential role for inexpensive disposable cards that can be offered at a discount. A transit agency does not have to find the best fare card, just one that works for its current and envisioned purposes.

SUMMARY

Technology providers advise transit agencies to purchase equipment that has been proven to be reliable and that is rugged enough to withstand a moving vehicle environment. The transit agency needs to make whatever internal changes are required to enhance system performance. A sense of ownership of the new technology, usually occurring at the agency's middle levels, is generally predictive of success, particularly in conjunction with a commitment from senior management. Care must be taken to maintain the new system to ensure continued high levels of performance. The technology providers view internal organizational problems and unnecessary customization as factors contributing to failed attempts to adopt new passenger counting technologies.

CHAPTER SEVEN

CASE STUDIES

Survey results and comments solicited from respondents provide an excellent overview of the major issues regarding passenger counting technologies and procedures. Following a review of these results, six agencies were selected as case study sites. Personnel directly involved with collection and analysis of ridership data and with decision-making regarding appropriate technologies and procedures at these agencies agreed to be interviewed by telephone. The case studies are intended to provide a more complete understanding of the evolution of passenger counting via different techniques.

The selection process for case studies focused on including agencies of various sizes in different parts of the country that use different procedures and on identifying systems that have achieved some level of success. Most of the agencies surveyed offered to serve as case study sites, and some that have not been able to implement or change passenger counting programs, due to problems with technology, lack of clear direction and support from upper management, or internal organizational disputes, would have provided instructive examples. One finding from this study, however, is that agencies face very similar problems in attempting to optimize passenger counting. The six agencies selected have overcome many of these common barriers. While they do not necessarily hold themselves up as examples of best practices, they have all managed to establish effective passenger counting programs that meet their needs.

The six case study agencies are:

- *Houston Metro (Metropolitan Transit Authority of Harris County, Texas).* Houston Metro operates over 1,200 buses on its fixed-route system, and relies on manual passenger counting using traffic checkers, pencil and paper for trip-level data and ERFs for system and route-level data.
- *TTDC (Tidewater Transit District Commission).* TTDC is a 146-bus system serving Norfolk, Virginia and surrounding areas. It uses hand-held equipment (portable computers) in conjunction with a manual traffic checking force to collect ridership data.
- *CTA (Chicago Transit Authority).* With over 2,000 buses in fixed-route service, CTA is the largest case study agency. CTA's responses concerned only its passenger counting procedures for buses. The agency developed innovative techniques to use electronic registering farebox data as a basis for its route and trip-level ridership counts. After a long process, CTA is now conducting a demonstration project using APC equipment.
- *Tri-Met (Tri-County Metropolitan Transportation District of Oregon).* Tri-Met is a multi-modal agency operating 600 buses along with its light rail system in Portland, Oregon. It has used APC units since the early 1980s, and is now converting its system from signpost to GPS and integrating the APCs with a new AVL system.
- *OC Transpo (Ottawa-Carleton Regional Transit Commission)* is an 800-bus system serving the Ottawa region in Ontario, Canada. OC Transpo is a long-time user of APCs for passenger counting.
- *SCAT (South Coast Area Transit)* is a 46-bus system in Ventura County, California. It is conducting one of the first and most extensive demonstration projects using smart card technology.

Survey responses for each case study agency are summarized to provide background information, followed by an in-depth description of the reasons for choosing certain technologies, benefits, problems, and advice for other agencies.

METROPOLITAN TRANSIT AUTHORITY OF HARRIS COUNTY (HOUSTON METRO)

Houston Metro's primary means of collecting ridership data is manual, using traffic checkers, pencil and paper. Electronic registering fareboxes are used to estimate monthly ridership totals from passenger fare activity counts, vehicle operator trip cards record ridership on employee shuttles, and onboard surveys are used for market research. The traffic checker data are used for service planning and scheduling purposes. A schedule of counting each route on weekdays every 3 years has been established, with weekend counts scheduled as needed. Data input is done manually (ERF data are retrieved at the garage). System and route-level ridership is summarized monthly based on ERF data. Manual commuter/park-and-ride counts are also reported on a monthly basis, while reports are generated for other routes as they are counted on the 3-year cycle. Houston Metro established a separate department Research, Evaluation and Trip Planning-that oversees most of the agency's data collection activities, including primary responsibility for ridership data collection. The data collection function was reassigned to this new department from Scheduling, which had geared data collection efforts solely to scheduling-related needs. Planning, Scheduling, and Budget/Finance have input into the data collection schedule.

Houston Metro uses five full-time traffic checkers who are former bus operators. The full-time equivalent of one data entry clerk enters the ridership data. There are seven temporary passenger count monitors whose primary duty is to assist in checking operator accuracy for farebox totals, but who are available one and one-half weeks per month to assist the fulltime checkers. As needed, Metro supplements staff with temporary personnel. This level of staffing has been reduced from 13 regular full-time and seven temporary traffic checkers in 1991, as introduction of more automated passenger data collection technology was planned. This new technology is not yet in place. APC purchase is still planned, while the investigation into using hand-held units has been delayed pending action on APCs.

Metro makes routine service changes three times per year, with major changes tending to occur in January. Due to requirements for public hearings and internal schedule reviews, Service Evaluation tries to have the necessary information ready 3 months prior to implementation.

When the current Manager of Service Evaluation assumed his duties in January 1995, current ridechecks were available for about 65 of the 100 routes in the system. This meant that the agency had no stop-level ridership data for about one-third of the routes. Service Evaluation developed a plan, with Planning and Scheduling review, intended to provide quality data in a timely fashion on all Metro service. As a result, an initial priority was to collect data on the smaller routes that are often overlooked. By 1998, Metro will have two counts on each route within the previous 4 years, at which time they may partially shift priorities back to focusing on the larger routes in the system.

Metro stresses the importance of developing a data collection plan that addresses all routes within the system. Like other systems, Metro responds to special requests that require a deviation from the established collection schedule, but notes a real difference in terms of awareness that such requests require a change in plans. It has become more possible to fit non-emergency special requests into the established plan, and thus to build a current database of ridership on all routes, as opposed to responding almost solely to other departments' priorities.

In addition to the five full-time traffic checkers, seven temporary passenger count monitors are available part-time, and outside temporary workers, and professional and administrative staff fill in on occasion to complete a check. Metro is pleased to have former bus operators as full-time checkers because they know the routes and are keenly aware of what can be done. Attendance and morale are not problems with the full-time checker force because they are eligible for bonus awards prorated for attendance. In the preceding 8 months, full-time checkers have missed only 5 days. By contrast, the temporary passenger count monitors average 86 percent attendance, meaning that one of the seven is absent on a typical day, and outside temporary workers show up 50 percent of the time. Use of full-time personnel who are eligible for attendance-based awards has been a very successful approach.

Metro has recently moved toward a policy of conducting weekday and weekend counts jointly on a given route. This provides a fuller picture of route dynamics, and also reduces errors by the checkers. Overall, data variation from route-level ERF estimates has decreased from 12 percent several years ago to five or six percent today, but Metro has found that the error rate is even lower when checkers are immediately familiar with the route (e.g., from just having completed a weekday check).

The reliability of core traffic-checking personnel is a key factor in Metro's satisfaction with manual data collection. The agency identifies several other benefits of manual passenger counting:

- If there are significant problems with a route or schedule, *the checkers function as an early warning system.* Use of former bus operators accentuates this ability, but experienced traffic checkers will also notice problems in the field. One example involved an extended route that encountered major on-time performance problems. The checkers noted that the extension involved a second crossing of railroad tracks that virtually ensured a delay on the route. Running time was increased, with a slight increase in headways, reliability was restored and ridership remained constant while operating costs were reduced. Conscientious traffic checkers provide important information to planners and schedulers who may not be able to get out into the field as often as they would like.
- *Checkers return forms with extensive notes on the back.* Service Evaluation finds these notes to be invaluable. Often these explain unusual discrepancies in running time or identify locations with awkward transfer or pulsing issues (such as an operator waiting for a transferring passenger at a transit center when the originating bus is running late). The explanatory or diagnostic power of these notes is something that cannot be obtained electronically.
- *A checker absence is readily observable, and missed data can be factored or the assignment repeated.* When technology malfunctions, there is a different response. In part this is due to an assumption that the technology will collect 100 percent of the information with immediate availability. The problem of identifying a malfunction can be more complex than simply noting that a checker is not present. Service Evaluation is particularly sensitive to this issue after a comment regarding the accuracy of ERF data on buses that experience mechanical difficulties in the field required the diversion of resources from other needs to identify the extent of this problem (as it turned out, the problem was insignificant).
- More data are sometimes collected than can be used, even relying on manual techniques and a 3-year data collection schedule for each route. The Service Evaluation Section and other departments cannot get to all the data. For example, the department recently sent results from 14 route ridechecks to the Schedules Section, followed by 10 more in the following week. The Schedules Section is hard-pressed in these circumstances to convert the ridecheck results to new schedules in a timely fashion. Given these constraints, there is no priority attached to the ability to count passengers more frequently.

Metro is very interested in what new technologies can offer, particularly in the area of data entry, a major bottleneck in the current system. It notes that ERFs were supposed to solve all problems in terms of aggregate ridership counts, but turned out to have difficulty in accounting for non-cash, nonmagnetic media boardings. The temporary passenger count monitors' tallies routinely differ from the ERFs by three percent, which can be very significant at an agency where even a 0.1 percent drop in ridership may elicit questions and concerns. Metro recognizes the benefits that will accrue when APCs, AVL, and ERFs all work together, but views this occurrence as still within the theoretical realm.

In the interim, Metro is an example of an agency that has established an effective manual data collection program that meets the agency's needs for ridership data. Key factors in this success are summarized as follows:

- Get Agency Support--Make sure that all internal clientele are in agreement with the data collection procedures and schedule and are willing to do what it takes to make the system work.
- Keep it Simple--Do not ever take for granted that data recipients will understand the data, even with extensive professional experience. Service Evaluation transmitted a spreadsheet with on-time performance data to another department and received a call asking why no trips were early. The spreadsheet formatting showed negative numbers in parentheses, not with a minus sign.
- Develop a Plan--Perhaps the corollary to this is: recognize that there will be deviations caused by special requests. Without a plan for data collection by route, however, special requests tend to edge out everything else.
- Conduct Joint Weekday and Weekend Checks--While this is not always possible due to personnel limits, Metro has found this technique to provide a more complete picture of the dynamics of ridership on a given route. It also reduces data variations, because the checkers are experienced with the route from the weekday checks.
- Use Checkers as Your Eyes and Ears--Encourage checkers to note unusual occurrences, unexpected ridership patterns, and apparent reasons for variations in running time. Good data result from a combination of quantitative and qualitative information.
- Use Full--Time Personnel and Reward Attendance Absenteeism has been noted as a major problem at agencies using manual data collection techniques, but Metro's checkers have excellent attendance rates. The reward system implemented at Metro encourages responsibility among the traffic checker personnel, which in turn has a major impact on the success of the data collection effort.

TIDEWATER TRANSPORTATION DISTRICT COMMISSION (TTDC)

TTDC collects detailed ridership data manually, using traffic checkers and hand-held units. Electronic registering fareboxes are used for aggregate system, route, and trip-level ridership counts. The traffic checker data include boardings and alightings by stop, which provide a route profile, and are used for all service planning and scheduling purposes. A schedule of counting each route once or twice each year on weekdays and once a year on Saturday has been established, with Sunday counts scheduled as needed. Laptop computers are used as hand-held units, and are directly connected to a host computer to upload and download data (ERF data are transmitted via a direct downlink). System and route-level ridership is summarized and performance measures are calculated monthly, based on ERF data. Annual reports include more detailed data collected manually with the hand-held units and summarized at the route segment and stop levels. The Planning Department has primary responsibility for ridership data collection. TTDC uses four full-time traffic checkers, one clerical person, and one half-time support person for passenger counting.

TTDC makes major service changes once a year, usually in October at the start of its fiscal year. Any minor problems are addressed 6 months later. Formerly, the agency worked on a 6 month cycle for making service changes of all types, but the costs involved in public information led to the new schedule. The ridership data collected with the hand-held units are the source data for current ridership, and are in constant use in analyzing the transit network.

Prior to converting to hand-held units, TTDC collected data manually using pencil and paper. When hand-held units became available, improved efficiency in data collection was the primary reason for the switch. Formerly, check sheets would have to be prepared and grouped on clipboards, and the resulting trip-by-trip data would be reconfigured by time of trip on a single big sheet. With hand-helds, required information for every route is stored on a host computer and downloaded to the laptops when needed. Ridership data are uploaded when the check is completed. Changes in schedules or stop lists are made in a single location (on the host computer).

TTDC is very satisfied with current data collection procedures. One problem reported by the agency is the rapidly increasing costs of laptop computers. As laptops become more sophisticated, it is increasingly difficult to find a simple, inexpensive machine. Because they are used extensively in the field, the laptops do get dirtier than office computers and require more frequent maintenance. Theft is a potential issue, although it has not occurred at TTDC. The small size of TTDC's checker force has resulted in close working relationships and a considerable degree of trust.

A final area of concern is devising a means of powering to ensure that the laptops work on the bus. The laptop battery is good for four hours, and each unit has a back-up battery. On the bus, TTDC has used plugs, adaptors, invertors, and cables to construct an effective (though aesthetically unattractive) means of delivering power to the laptops.

In converting from paper and pencil to hand-held units, TTDC found that other changes were required. Programs were developed to keep stop inventories, headway sheets, and schedules current. Links between scheduling and data collection databases were established so that changes in stops, schedules, and route descriptions occur automatically in both. Procedures were established to address short-lines, interlines, and branches. Download and upload programs allow information to be passed routinely between the host computer and the laptops. Data analysis and reporting software converts ridership data into immediately useful formats. While all these programs were being developed, the agency also switched from a mini-computer to a PC-based system. A local programming company provided custom programming for TTDC. While this required a significant time investment up front, the data collection system now runs with little intervention.

TTDC recognized several benefits in the conversion to hand-held units. Most of these flowed directly from the elimination of the intermediate step of inputting data manually. Primary benefits include:

- Faster turnaround--The time between data collection and analysis has been reduced significantly, and ridership data are available more quickly than under the pencil and paper procedures.
- Improved accuracy--Elimination of manual data input means that there is one less source of error in the data collection process.
- More efficient use of personnel--Traffic checkers are now focused full-time on collecting data and keeping files updated. More routes and/or trips can be checked within a given period of time, and checkers are now being used to provide assistance with customer service functions.
- Sense of ownership--In going through the process of adopting a new passenger counting system, TTDC found that those involved developed a strong sense of ownership in the new system. This has helped to ensure support for the system throughout the agency.

TTDC currently has a signpost-based AVL system, and is considering a change to APC with the next generation of AVL. A more immediate priority at the agency is integrating ridership data with the route network in a Geographic Information System environment. Functionality is the key: the first step is to display ridership data in the way it is currently used, so that it can be used immediately. TTDC anticipates that additional uses will develop once the systems are integrated.

In summary, TTDC is very pleased with the use of handheld units to collect ridership information. The system works very well, and provides information that is used constantly by planning and scheduling. The agency offers the following observations based on its experience in converting to and using hand-held units:

- Use generic computer equipment, such as laptops. Handheld units manufactured specifically to count data are available, but their purchase locks an agency into one specific vendor. Laptop computers avoid this problem, since there are obviously multiple vendors.
- Be prepared to devote time initially to develop databases and programs to work with the hand-held units. TTDC spent considerable time up-front, but now has a system that nearly runs itself.
- Involve all data users in the process. Adopting new technology can be stressful and difficult, but it is possible to build a sense of ownership in the process by involving all of the appropriate parties. This sense of ownership ensures continued support for the data collection system as it matures.

CHICAGO TRANSIT AUTHORITY (CTA)

CTA collects ridership data via electronic registering fareboxes and manually, using traffic checkers, pencil and paper. ERF data are the primary data, used for service planning, ridership trends, and performance reports. CTA has developed techniques to adjust farebox-generated ridership data for operator error through sampled surveys. These adjustment factors are applied automatically and updated through periodic re-surveys. Data collected manually by paper and pencil are used solely by the Schedules Department. System and route-level ridership is summarized monthly, and performance measures are calculated on a quarterly basis. ERF data input is done via direct downlinks. Manual counts for scheduling purposes remain on paper. The planning and scheduling departments have primary responsibility for ridership data collection.

All of these procedures are changing. CTA is completing a demonstration of APC units on 25 buses and is moving forward with the implementation of APCs.

CTA currently has 14 traffic checkers for its entire system (bus and rail), and also relies on six clerical and one professional staff in the Traffic and Analysis Section. Seven traffic checker positions were eliminated concurrent with APC system development. Resulting staff levels are insufficient to conduct all-day weekday and any weekend checks. A current buy-out proposal is expected to reduce the current checker staff even further, and these positions will not be filled.

The development of farebox adjustment factors to count ridership by route and by hour is a notable example of a transit agency's general process of attempting to extract the most information from available data. However, CTA rated fareboxes as not very useful at the trip level and indicated that ratings at other sub-route levels were not applicable, since ERFs do not produce data at those levels. Despite the unavailability of detailed data, CTA achieved considerable success in being able to use farebox data for service planning purposes, primarily by extracting ridership captured at the trip level by route and by hour. The only ERF-related problem noted was operator noncompliance in following the proper sign-on procedures and recording each passenger boarding by fare category correctly.

Continuing interest in APCs reflected the fact that ERF data are not truly suitable for detailed route analysis. As noted in the introduction, ERF ridership data are collected on a trip-by-trip basis. These can be combined to provide route-level and system-level ridership totals, but cannot be disaggregated to yield route segment or stop-level data. As CTA notes, the reliability of data on a specific trip is dependent on operator compliance with entering the correct code to indicate the start of a new trip. Thus, ERF data cannot provide information regarding key stops along a route with significant boarding and alighting activity, nor do ERFs have the capability of recording actual time at specific timepoints along the route. APCs use the stop as the basic unit at which passenger activity is recorded, and have the capability to provide a time stamp at every stop. APC data are considerably more useful for service planners and schedulers because of the disaggregate nature of the ridership count.

The length of time involved in the decision to go ahead with APC is typical of many agencies. As changes occurred in senior management, APC priority within the agency also changed. Thus, the CTA process highlights the importance of commitment by senior management to whatever data collection technology is selected. Another reason for the lengthy decision-making period was CTA's approach. The agency was both cautious and demanding, very wary of being taken for a ride and very insistent on getting exactly what it needed.

Results of the recently concluded APC demonstration project (using a signpost-based system) revealed several important lessons, the first of which was the importance of conducting a demonstration. The agency was surprised that, despite its best efforts, it had not fully specified all needed system elements. Hardware was the least important part of the overall system. Sources of route-level inventory data and post-collection report processing proved to be much more critical to the effective functioning of the APC system.

Bus stop inventory, route descriptions, and scheduling information are key inputs to APC, and the demonstration project showed that these databases needed additional work. For example, the output of schedules was flawed, and program modifications were needed to produce internally consistent schedules. A clear need emerged to dedicate staff to data maintenance. In terms of data processing, the need for separate work, calibration, and data storage areas led to a reconfiguration of the computer network. The process of software modification can reveal how the data system really works. The demonstration project emphasized the need for an agency to get its own house in order before adopting a new technology like APC.

CTA clearly endorses the consensus that support of senior management is necessary to the success of a technology changeover such as introducing APCs. At the same time, the system should be designed at lower levels, with the participation of those who will use the results, instead of being dictated in top-down fashion. The lower-level design must involve a considerable amount of give-and-take. Some departments may insist on having ridership data in exactly the same format, even though this may not suit broader agency needs. The discipline forced on departments by notification that they would lose all traffic checkers by a certain date (an approach taken by Montreal) can help to ensure cooperation in making sure the new APC system will work.

The APC demonstration also showed the importance of interdepartmental cooperation and direction from management in ensuring success. APCs were used to gather detailed data on five routes that were strong candidates for pruning or possibly discontinuation. At one garage where there was a supportive manager, the APC units produced very good data. At the other garage, where the direction was along the lines of "fit this in where possible," the APC units produced marginal data.

CTA was obviously very pleased with the APC demonstration project, since it is implementing an APC-based system. The staff reported that accuracy was better than expected, and the detailed level of data produced was remarkable. Unexpected uses have already been found for APC data, such as responding in detail to a query from senior management regarding the possibility of increasing speed on a specific route by reducing the number of bus stops. The APC stop-level data showed several stops that were not being used, including one that was assumed to be an important transfer point.

There is an awareness that adoption of APC means a transition from traffic checkers to analysts in management positions, who will require training to develop and polish the necessary skills. Coincidentally, a significant portion of the scheduling department is taking an early buy-out offer, creating an opportunity to bring in new and possibly different types of people (in terms of education and experience) and train them from the outset on use of APC data.

CTA suggests that several lessons from its APC demonstration are applicable to agencies considering APCs or some other form of technology upgrade:

- Visit other systems or invite key personnel to visit you--Ask the agencies that have been through the process to lay out what you need. Take their advice and get your own house in order before going out to talk with vendors.
- Set up your database inventories--As noted, bus stop inventories, headway sheets, and schedule information are key items.
- Build flexibility into your reporting system--Data tend to find their own uses. Decide on standard reports that will be needed on a recurring basis, but design the ridership database as flexibly as possible to permit special queries.
- Get firm support from management--Experience with the APC demonstration suggests that success is ultimately determined by support from management.
- Keep the faith--Converting to APCs is harder than expected, and may take longer than expected, but it can be done successfully.

TRI-COUNTY METROPOLITAN TRANSPORTATION DISTRICT OF OREGON (TRI-MET)

Tri-Met uses electronic registering fareboxes for revenue calculations and for determining special boarding counts (i.e., lift and bicycle), and uses APCs to summarize schedule adherence and to count ridership at the system, route, trip, route segment, and now stop levels. APC data are used for all service planning and scheduling purposes. The APCs count passengers via infrared beams. Weekday and weekend counts of each route are conducted during each driver sign-up (or nearly once every quarter), with a goal of sampling each trip five times during the quarter by rotating APC-equipped buses throughout the system. Ridership data are retrieved from the buses at the garage automatically via infrared at the farebox collection point. System-level ridership is summarized monthly, while data at sub-system levels are available daily on request. The Operations Planning and Analysis Department has primary responsibility for ridership data collection, and makes routine service changes in conjunction with its quarterly driver sign-ups using the APC data.

Tri-Met eliminated one supervisory and six traffic checker positions when the APC system became operational in 198384. There are no longer any traffic checkers at Tri-Met. Staff assigned to carry out the passenger counting program includes about 75 percent of one professional, five percent of one clerical, and 25 percent of one electronic maintenance person's time. Capital costs for an APC unit have declined with the addition of an AVL system, from an estimated $5,000 per APC unit to $1,000. Annual operating costs are estimated at $70,000, and annual maintenance costs at $15,000. Ninety buses, or about 15 percent of the fleet, are equipped with APCs. There are plans to expand this number by 110 buses in the current fiscal year, bringing the percentage of APC-equipped buses to 33 percent of the fleet, and possibly to move toward a 100 percent APC fleet within the next few years. The cost reduction as a result of AVL and increased flexibility in bus assignments are the principal reasons for APC expansion plans.

APCs were introduced at Tri-Met approximately 15 years ago to achieve lower cost and greater efficiencies in the area of passenger counting. Implementation proceeded incrementally, from use for system and route-level ridership to a focus at the trip level, then at the route segment level and finally, with the pending reliability of AVL, at the stop level. Interestingly, the pre-AVL system was completely odometer-based, with no signposts or GPS. Reliance on odometers meant that the agency needed to upgrade its schedule mileage by route to ensure that APCs worked accurately. In conjunction with odometer data and time stamps, Tri-Met used layovers as virtual signposts. After the trip-level data were established as accurate, the agency then would segment portions of routes by time points, based on the distance traveled. Tri-Met was not confident enough in stop-by-stop location via the odometers alone to use stop-level data.

Now, with a GPS-based AVL system integrated with the APCs, each boarding and alighting is recorded by the APC unit while AVL matches the information with the correct stop. Tri-Met is in the process of converting its software to make full use of the newly captured data, while other projects (such as the bus shelter placement) are already showing interest in the stop-level information. Software conversion to stop-level reporting will take some time, but the agency made the decision to do the conversion while keeping the current APC reporting system up and running.

While the AVL-APC integration is allowing Tri-Met to do even more with its passenger counting program, the agency's considerable success with adoption and use of APCs as a stand-alone component for over a decade may be more relevant for other systems considering APC technology. As noted above, Tri-Met proceeded incrementally in terms of making use of the APCs, and this approach helped in terms of establishing organizational responsibilities. The agency was fortunate to have established programming positions within the Planning department, ensuring that needed work on APC-related software received a high priority. There were still dealings with other key departments, including Information Systems and Maintenance. The APC project manager noted that he was successful in transferring responsibility for maintaining APC equipment to Maintenance only after the third attempt.

It also took time to ensure correct APC dispatching. After several different approaches, the Maintenance and Planning departments worked out an agreement under which Planning asks for only 60 percent of APC buses to be specifically assigned. This target is reachable every day and avoids the problem of the assignment clerk being forced to decide which assignments should be skipped in the event that APC buses are not available due to maintenance or other reasons. This compromise has worked successfully even at times of high turnover among assignment clerks.

In the pre-AVL system, ridership data were accumulated on a bus block assignment basis. Two different methods have been used to match ridership data to bus assignment: either the assignment clerk would assign a specific pre-programmed bus or the bus operator would program the bus before leaving the garage. The integration of ridership data with schedule information was part of the post-processing program. Tri-Met has noted no real change in skill levels required when it comes to analyzing ridership data collected by APCs. The change has occurred in the amount of data and number of analytical tools available. More frequent data collection has resulted in enabling changes to happen more quickly. When questions arise, ridership data are immediately available or can be obtained quickly, making the department and the agency more responsive.

Data availability, with the consequent ability to respond quickly, is one of the benefits of APCs. The ability to collect more detailed data is also important. A third benefit is cost savings. One reason that Tri-Met adopted APCs is that an APC-based ridership counting process is less expensive and more accurate than a manual process. Implementation of an AVL system has reduced the cost of APCs, because the new APCs do not need data storage, data transmission, and odometer interface capabilities that are now handled by AVL.

One of the problems still faced at Tri-Met is getting priority for APCs in the Maintenance department. The problem is not necessarily solvable, since Maintenance is very clear that safety issues (radios) and customer service issues (destination signs) have greater priority than APCs. One possible solution is to assume budgetary responsibility for half of a full-time maintenance person, who can then be devoted (half-time) to APC maintenance needs. Another previous maintenance related problem was the high-pressure steam wash used for bus interiors. This was fixed by having certain APC parts epoxied. These cannot be repaired and must be replaced when they break down, but now break down much less frequently.

Accuracy of the data is another problem for Tri-Met with its APC equipment. Some counters do not yield a consistent set of counts, while others are consistently high or low. The agency has never tried to determine whether the problem lies with the vendor, the technology, or its own installation process. What the agency did was to develop an algorithm that corrects counts based on the counters' history, but the correction is made in the post-processing phase. As a result, real-time data cannot be supplied with confidence.

Tri-Met points out that the definition of accuracy is inconsistent within the industry. A typical definition is that boardings and alightings must be counted to within ± 10 percent or ± 3 passengers at the trip level, whichever is greater. Tri-Met specifies that, for 90 percent of all runs within a 30-day period, all boardings must be correctly counted at 90 percent of all passenger stops, and all alightings must be correctly counted at 90 percent of all passenger stops. The APC Project Manager noted that he has seen four or five different specifications regarding accuracy, but has never seen a standard. Parenthetically, other agencies have considered specifications that take passenger loads into account along with boardings and alightings.

Overall, Tri-Met has been satisfied with its APC system, and views the addition of an AVL system as a major improvement that opens up a variety of new analytical possibilities. With the reduced cost of APCs, due to many functions now being handled by AVL, Tri-Met is planning to expand its APC fleet to a size larger than any other APC agency included in the survey. Tri-Met's experience with APCs results in the following suggestions for agencies considering this technology:

- Integrate with AVL--Accurate locational referencing enhances APC capabilities. AVL reduces the cost of new APC units, which no longer need to handle data storage, data transmission, and odometer interface.
- Plan and budget for maintenance, and clarify responsibilities--Effective maintenance is one of the keys to making an APC program work.
- Get a commitment from management--This is critical to success. Senior management must understand the usefulness of the data to be collected and the importance of the purposes for which the data can be used. From management's perspective, enhanced responsiveness to queries and reduced turnaround time are important improvements that APCs can offer.
- APCs can be implemented incrementally--Tri-Met began by equipping 10 to 12 buses, and had a single person responsible for management, programming, maintenance, and procurement. At smaller systems with relatively simple route structures, a high level of automation in terms of providing schedule information may not be needed. An incremental approach can work at any system, at least in terms of the number of APC units. Related software must be developed largely at the same time as the initial implementation, but will also be enhanced incrementally.

OTTAWA-CARLETON REGIONAL TRANSIT COMMISSION (OC TRANSPO)

OC Transpo relies on a signpost-based APC system for all ridership data collection. Boardings and alightings are counted via infrared beams. Counts are scheduled on a quarterly basis (coinciding with the four annual booking periods) for each weekday route and on a biannual basis for each weekend route. All weekday trips are scheduled to be sampled at least once each booking period, and all weekend trips are scheduled to be sampled at least once every other booking period. On average, each scheduled trip is captured four times. Data collected during the day are stored onboard in memory and are downloaded remotely each night via radio. OC Transpo summarizes system-level ridership monthly (based on revenue and pass sales analysis) and APC ridership data at more detailed levels quarterly. The Planning Department has primary responsibility for ridership data collection.

OC Transpo has no traffic checkers. In the early 1980s, eight traffic checkers were redeployed within the agency after APCs were on line. Staffing needs for passenger counting include 2.5 professionals, one hardware maintenance employee, and a half-time student from a local engineering college who assists with equipment maintenance. APCs did require a change in skill level in the areas of computer usage, hardware maintenance, system development, and quantitative analysis.

The estimated replacement cost for capital equipment and software is $650,000 for hardware and $250,000 for software. OC Transpo reports an annual operating cost of $110,000 and an annual maintenance cost of $95,000 for its passenger counting program. The maintenance cost includes staff resources and materials for both the hardware and software components. Eleven percent of its fleet, or 86 buses, are equipped with APC units.

The Ottawa-Carleton region experienced tremendous growth during the 1970s, and OC Transpo realized that a limited traffic checker force was not producing coordinated information that the planners needed. Backed with an absolute commitment from management, the agency, in 1978, moved ahead with the decision to automate the data collection and analysis function based on an APC system. Software problems initially limited the effectiveness of APCs, and the payback for the capital investment was questionable in the early days, but in 1986 the software was thoroughly revised, with periodic minor upgrades in subsequent years. Ridership data are transmitted via radio and processed overnight. Sophisticated diagnostics can identify when a unit is not working properly, to the detailed level of which beam is the likely culprit. End users (managers, planners, and schedulers) obtain information from the system through the APC database staff. Requests are usually processed within 24 hours. The end users are pleased with this procedure, because the data managers are intimately familiar with all aspects of the data and will determine whether ridership data on a particular route constitute an adequate sample for their purposes.

The agency has bought into the use of APCs, and recognizes the data collection function as an equal and integral part of the overall transit operation. The planners and schedulers who are the primary users of the APC data have also accepted the system totally. Over time, a variety of standard analyses and reports have been developed, including those listed below.

- Average loads and passenger activity (boardings and alightings) along a route at the bus stop level.
- Distribution of running times along a route by timepoint section (or any stop-to-stop section) by hourly increments throughout the day. This is used to calibrate scheduled running time so as to match actual travel times on the route.
- Route performance relative to service standards. OC Transpo has developed service standards for transitway, base and regular route categories, and uses APC data to analyze performance by route category, route, and five major time periods. The system produces revenue to cost ratios for each route by major time period. The analysis highlights poorly performing routes as candidates for remedial action. Like all transit systems, the agency faces tradeoffs at the Board level between performance and mobility. The detailed performance analysis relative to the cost recovery target provides the Board with the necessary information to make its decisions.

- On-time performance. The APC data permit schedule adherence at the bus stop level to be determined. When first conducted, this analysis revealed that many buses were leaving stops earlier than scheduled, due largely to how running times were being assigned to routes. Ongoing revisions to scheduling practices and improved supervision in the field are solving the problem.
- Area analysis. Each bus stop has a unique number, and can be grouped to determine boardings and alightings within an area by day and time period. Individual stops are analyzed and prioritized for potential shelter installation based on the volumes of boarding passengers.
- Screenline crossings. This reports the total passenger volume on buses crossing a cordon line. One important use of the data is to augment the screenline count program carried out by the Regional Transportation Department to determine modal split. The process of identifying screenline locations within the APC system is labor intensive and can only be simplified when APC is linked to GIS in the future.
- Travel times along a corridor. This information is being used to identify major corridors that can benefit most from bus priority treatments. OC Transpo can break down bus travel times into individual components: boarding/alighting; access to/egress from bus stops; idling in traffic; caught in traffic congestion; and moving. Moving speed and total speed can be calculated, and corridors can be ranked. This activity had previously been done manually.
- Special ad hoc queries by day type, time of day, route, segment, etc.

OC Transpo's APC system uses 40 signposts as locational references, strategically situated throughout the region to achieve maximum route coverage. The APC units log activity whenever certain events occur. These include bus stops, idle time, stop-and-go time, and signposts along a route. Odometer mileage is used to match stops relative to signposts, trip origin, and trip end. Post-processing verification ensures that at least two-thirds of all stops on a given trip record are within a specified distance of their actual location, or the trip is discarded. The agency has a high level of confidence in its signpost system. It recognizes the potential benefits of GPS, but cannot justify the expense of installing a new system solely on the basis of passenger counting activity. If the Commission's AVL system is upgraded to use GPS, then APC will be modified to take advantage of it.

The process of establishing APCs as an integral part of an agency's day-to-day operation is not simple. There is a huge amount of work at the outset, and decisions are needed regarding responsibilities for installation and maintenance. At OC Transpo, the hardware installation and maintenance functions are cooperatively shared between Planning's APC technologist and the Equipment department's electrical and body shop staff. Software in many respects presents a larger challenge than hardware. The level of programming effort depends partly on the existing level of sophistication within the organization. The major issue is getting people within the agency to buy into the APC system and change how they view data collection. Management support, which was strong and consistent at OC Transpo, ultimately determines the success of this effort.

One key to smooth operation at OC Transpo has been the integration of APC bus assignment with the dispatching system. The strength of the APC database is based on the results of the sampling approach. Determining which vehicle blocks are to be assigned an APC bus the following day is automated within the APC software program. Vehicle blocks selected are electronically passed along to the bus starting module overnight, so that the bus starter is flagged with the APC assignments for the day. Attempts are made to park APC buses in dedicated lanes, so that a driver assigned to an APC run can be sent to the appropriate lane and take the next bus in line. Operations, and particularly dispatch, now reports few problems with APC bus assignment, but the agency suggests that this process of making APCs a routine part of operations will require considerable time (perhaps one year) to be fully integrated as the norm.

The principal benefit of an APC system for OC Transpo lies in its role as primary provider of all planning and scheduling data. Benefits include:

- A fully automated system collecting data 24 hours per day, seven days a week
- An extensive database for each booking period covering all routes
- A variety of standard reports that users are comfortable with, as well as the facilitation of ad hoc queries
- Better decision making is possible because ridership data are available
- Time use information (travel times and schedule adherence) is available along with passenger count data.

Problems encountered by OC Transpo in the early years of development included acceptance by users (improved dramatically over time), software development, data storage prior to automated radio-based data transfer (APC buses cannot store more than 3 or 4 days of data), and maintenance. Other APC agencies have cited OC Transpo as not having significant maintenance problems, and this can be attributed to a constant effort to keep on top of maintenance needs and to the presence of an electronic technologist as part of the APC team. OC Transpo would like to see integration of its APC system with GIS, the use of which could simplify area and screenline report inputs and allow graphical representation of the data.

Within the transit industry, there has been concern over the ability to use APC systems with low-floor buses. OC Transpo has successfully equipped a low-floor Orion II bus, and reports that the beam-based counts are providing reliable data. With the proviso that passenger boardings be single-streamed (achieved through placement of stanchions, for example), the agency does not anticipate problems with standard 40-ft low-floor vehicles.

Many agencies have looked to OC Transpo over the years for advice on implementing APC systems. Experience over the past two decades has suggested the following approaches to be most beneficial:

- Obtain a strong commitment from management--This is the most critical factor in determining the ultimate success of an APC passenger counting program. All other problems can be solved if this commitment is present. In particular, management commitment allows you to develop standard procedures to be followed throughout the agency.
- Visit and learn from other transit agencies--APC technology is still viewed as new by many agencies, but there is a considerable and growing body of experience. Tapping this experience avoids recreating the wheel, increases awareness of potential pitfalls, and provides concrete examples of how solutions to various problems have been reached and implemented.
- Put a high priority on maintenance--Preventive maintenance and early diagnosis of problems keep the APC system operating effectively.
- Address software issues--Once routine maintenance procedures are established and followed, hardware is rarely the problem. APCs require a new approach to data collection, and existing databases will need upgrading. Considerable effort is involved up front in APC implementation, but the results are clearly worth the effort.
- Budget for system improvements every year--These generally relate to data processing and reporting enhancements. The amount can be modest, but it will permit continued upgrades to the system.

SOUTH COAST AREA TRANSIT (SCAT)

SCAT is a small (46-bus) transit system serving Oxnard and surrounding areas of Ventura County, California. Until recently, SCAT has counted ridership using GFI fareboxes at the system and route levels and interns (supplemented when necessary by temporary workers) with pencil and paper or handheld units at the route, trip, and trip segment levels. SCAT is now a beta test site for a smart card and an APC demonstration project. The smart card data provide origins and destinations, and have the potential to be useful for service planning purposes as the use of smart cards by riders increases. An evaluation of the smart card demonstration is close to completion. Both the smart card and the APC systems use GPS vehicle location to determine at which stop boardings occur.

SCAT is planning to use APC data to conduct more detailed service evaluations and to respond to Board inquiries in a more timely fashion. A permanent schedule for APC data collection has not yet been set, but SCAT intends to evaluate recently instituted evening service by rotating the APC-equipped buses through the evening runs. Ridership data for smart cards and APCs are retrieved from the buses at the garage. The Planning and Marketing Department will have primary responsibility for ridership data collection after the contractor completes its contract period.

South Coast Area Transit was originally approached to be a beta test site for a smart card and APC system. Due to limited size of staff and fleet, the agency declined the original offer, but the Ventura County Transportation Commission was intrigued with the idea and recommended that all transit agencies (SCAT and municipal systems) in the county participate. After reconsidering the potential benefits, SCAT agreed to participate. One of the more attractive elements of the arrangement is that the agency can keep the equipment after the demonstration is completed. Because of this arrangement and the fact that the demonstration is ongoing at this time, SCAT could not provide detailed capital, operating and maintenance costs associated with smart cards or APCs.

The smart cards replaced the Countywide Passport, a multi-agency pass that was accepted by all transit agencies within Ventura County. Each transit agency still offers its own monthly pass, and the price of a single-agency pass is less than the price of a smart card. Thus, the primary market for smart cards to date includes riders who use more than one transit agency on a regular basis. Limited usage of the smart card limits the usefulness of the data to any one agency, because the data represent an atypical sample of ridership (i.e., those who use more than one system). The smart card data provide insights on multi-agency ridership patterns that were previously difficult to track.

Customers reacted positively to the smart card, which was viewed as the Passport in a slightly different form. The local newspaper did a feature article in which some riders expressed concern over the "big brother" aspects of the smart card, but most riders were unaware that they were using a cutting-edge technology *(14)*.

SCAT makes routine service changes once a year, with major changes to the route network coinciding with periodic larger studies. The APC system will replace the manual procedures that formerly provided the data used to identify needed service changes. At the time of program initiation, all but two of SCAT's buses were equipped with smart card readers. Since that time, nine replacement buses have been added to the fleet, resulting in a fleet size of 46. Thirty-five buses, or 76 percent of the current fleet, are equipped with smart card readers. Nine buses, or 20 percent of the fleet, are equipped with APC units.

SCAT does not envision any changes in personnel as a result of adopting smart cards and APC. As with many smaller agencies, SCAT did not have a dedicated traffic checking force. Interns formerly handled data collection, and will be reassigned to other functions.

It is too soon to quantify improvements associated with smart cards and APCs at SCAT, but the agency recognizes several potential benefits. The key benefit is improved route evaluation and planning. Smart cards are providing new information on multi-agency trips within Ventura County, and APC data will enhance SCAT's ability to evaluate service. The first major example of this ability is the upcoming evaluation of new evening service. SCAT also sees as important the ability to make a commitment (to its Board of Directors, for example) to conduct detailed ridership counts on a routine basis, thus solidifying the Board's confidence in the agency's day-today oversight of its system. Related to this is the ability to respond to inquiries from the agency's Board of Directors and others in a more timely fashion.

The beta-test nature of the demonstration project was responsible for some of the problems that ensued. Communication problems among the softwares of the smart card issuing equipment, the card reader, and the passenger card were traced to different software versions. In order to test various configurations, the vendor would frequently switch equipment and revise software; once a specific version was made to work, it was often replaced by another for testing. This caused frustration among maintenance personnel, who were incorrectly perceived by many bus operators as being responsible for smart card equipment maintenance, as well as among bus operators, who dealt on a daily basis with the inconsistency of the equipment's performance. Administrative personnel who sold the smart cards did not have the technical knowledge to correct any software problems that arose. Given SCAT's small size, this resulted in managers becoming involved in day-to-day trouble-shooting. Finally, the operators bore the brunt of customer dissatisfaction when a card would not function properly.

Overall, SCAT is satisfied with the very limited results to date of the smart card and APC demonstration project, and envisions additional and more routine applications as the system matures from its demonstration status. The agency recognizes that market penetration of smart cards is the key to obtaining useful ridership data. SCAT offers the following advice for agencies considering either smart cards or APCs:

- Be absolutely clear regarding roles--Each department needs to understand its responsibilities in making implementation successful. Operations, maintenance, administration, and planning must clearly understand what they need to do as departments to ensure a smooth transition and to work as a team in trouble-shooting. The role of the maintenance department can be particularly important, whether it is to maintain the equipment or to facilitate maintenance by the equipment contractor.
- Research training needs--Understand the time commitment required both to train employees in retrieving and formatting data and to carry out these tasks.
- Work cooperatively with all departments involved--Inform the operators of the value of the new technology to gain their support. Allow them to anticipate problems.
- Be aware that implementation will be harder than expected--Agencies typically adopt new technologies with a focus on benefits and do not always fully understand the difficulty of adapting all of their related procedures to function in coordination with the new technology. The beta-test nature of the SCAT experience intensified this problem, but the other case studies and survey responses consistently show a longer-than-anticipated break-in period and the emergence of unexpected issues.

CHAPTER EIGHT

CONCLUSIONS

Passenger counting remains an important function at transit agencies, which tend to measure their success by the number of riders they carry. Systemwide and route-level ridership are of interest throughout the transit agency. Ridership data at disaggregate levels, by route segment, stop, trip, and time of day, are generally utilized by service planning and scheduling departments for detailed analyses of transit routes and service levels. In the constrained fiscal environment affecting most transit agencies in recent years, these types of analyses have often resulted in an ability to reallocate transit resources to more closely match demand patterns.

Passenger counting technologies and procedures have evolved considerably from their paper and pencil origins, although paper and pencil continue to be the preferred mode of data collection at many agencies, large and small. Choices now include hand-held units for use by checkers on the buses, automated passenger counting (APC) systems, and electronic registering fareboxes (ERFs). Smart cards also offer potential in the area of passenger counting, but it is premature to place them in the same category as the other options. Many agencies use different technologies for different purposes.

Smart cards are the most recent development in this area, and are still in the demonstration or preliminary installation phase on bus systems in North America. They potentially offer the ability to combine boarding and fare information that can be recorded automatically, although cash boardings must still be accounted for in anything less than a 100 percent smart card system. It is important to note that passenger counting is not the major purpose of smart cards; fare collection issues are the driving force in the development of this technology. Depending on the market penetration of smart cards, passenger counting may have significant potential as a secondary function of this developing fare medium.

APCs have been in use in a mature state for over a decade, but are still viewed by many agencies as a new technology. APCs provide transit agencies with extensive capabilities to collect detailed, stop-level ridership and time-based data that can be of great practical use to planners and schedulers. Signposts and GPS are most typically used to locate transit vehicles. Integration with new GPS-based AVL systems offers locational referencing and reduced costs per APC unit, which no longer needs to be equipped with locational components. APC technology continues to evolve to meet challenges offered by different vehicle types, such as low-floor buses. APCs are most useful at the trip, route segment, and stop levels. The automated radio transmittal of data is a preferred method of data retrieval that also greatly reduces turnaround time. Agencies with APC equipment generally collect ridership data on a given route more frequently than can be done using manual techniques.

Electronic registering fareboxes are virtually standard equipment in the United States, although not in Canada. Revenue-related issues have been the primary reason for the adoption of ERFs by transit agencies; passenger counting is a secondary function that can require operator intervention for non-cash fares. ERFs are most useful at the system and route levels in terms of counting riders. Some agencies (notably Chicago Transit Authority) have developed factors to convert revenue totals by route directly to ridership. A common source of frustration with ERFs is the need for operator intervention to obtain accurate data, both in terms of operator sign-on procedures and the recording of boardings by certain types of fare media. ERF data are commonly used to track overall ridership trends. Passenger counting at the route level can be achieved only with full operator compliance with sign-on and passenger recording procedures, particularly on systems with significant interlining of routes.

Hand-held units are used by traffic checkers to record passenger activity along a bus route. A key advantage for handheld units over paper and pencil techniques is that the data can be uploaded automatically, eliminating the need for manual data input and decreasing turnaround time. Hand-held units are used to collect route, trip, and stop-level information. Some agencies use manufactured units, while others rely on laptop computers. Powering hand-held units can be a problem.

Ridership counting with paper and pencil has not yet been replaced by more advanced technologies. Familiarity with the procedures involved is viewed as a benefit. Agencies such as Houston Metro have been successful in establishing passenger counting programs using manual techniques that provide sufficient ridership data to meet agency needs. Manual data collection techniques are time-consuming and labor intensive, and manual data input introduces another source of data error. These techniques do not require capital investment, and some observers have questioned whether transit agencies have the resources to analyze ridership data more frequently. Establishing a plan and schedule for manual data collection is important in ensuring that all routes are covered on a systematic basis.

Key findings and conclusions of this synthesis are summarized in the following paragraphs.

Procedures are more important than technology. The establishment of passenger counting procedures is much more critical to success than the choice of technology, as shown by successful programs using manual techniques at Houston Metro and other agencies around the country. Transit as an industry tends to focus too much on the hardware side and not enough on the need and uses for ridership data within an agency.

Internal changes are necessary to ensure the success of new passenger counting technologies. A significant investment in time and effort is needed in the early stages to update internal databases and analytical techniques to ensure that correct stop and schedule data are available and that the ridership data can be readily used. Steps must also be taken to ensure that the system receives the priority it needs and to train staff in its maintenance and usage. In a very real sense, a passenger counting system does not stand alone.

Visit and learn from other agencies before deciding on a new passenger counting technology. This emerged as a strong recommendation from both the surveys and the case studies. While each agency obviously has unique aspects, the process of implementing new passenger counting technologies is very similar throughout the industry. Instead of re-inventing the wheel, a savvy agency can draw on the experiences of others in planning its own implementation of new technology.

Unnecessary customization should be avoided. This phenomenon is related to the emphasis on technology seen within the transit industry. Attempts to redesign what is available on the market to make one's own system unique or better almost always result in failure. Most installations require a fair degree of customization to match agency needs, but there are examples, such as Lane Transit District in Eugene, Oregon, where a good passenger counting system has been established by combining standardized APC modules.

A strong commitment from senior management is required. Adoption of new passenger counting technologies and procedures involves changes in departmental functions and responsibilities. Support from the general manager raises the priority attached to passenger counting and is of great assistance in ensuring cooperation among the various departments involved.

Active management of the passenger counting system is critical to success. Senior management support is vital, but agencies that have successfully adopted new technologies are characterized by a mid-level person who assumes responsibility for the system and takes the necessary action to ensure its proper functioning. Without this sense of ownership, the project can fall between the bureaucratic cracks. Internal agency politics can lead to the same result. The responsible person typically has oversight over ridership data collection and/or use.

Responsibilities must be clarified. Agencies that have strong service planning and scheduling departments and take a proactive approach to making changes to their routes and networks tend to make the best use of advanced passenger counting technologies. However, adopting a new technology is not a step taken in isolation. Internal working relationships (between planning and dispatching, for example) are likely to change noticeably. The agency must be prepared and willing to make necessary changes in ancillary procedures to make maximum use of advanced passenger counting technologies. Cooperation from several departments within the agency is needed, and does not necessarily happen overnight. Clarification of responsibilities at the outset is advised by agencies that have been through the process. Obtaining buy-in from the bus operators can pose particular problems beyond interdepartmental cooperation. The additional operator duties required by ERFs are typically a negotiated item with the union. To promote cooperation with use of APCs, at least one agency implemented a policy that APC information could not be used as a basis for disciplinary action against an operator.

Advanced passenger counting technologies offer several benefits. Among benefits cited by survey and case study agencies are more frequent data collection, a reduction in turnaround time, the ability to analyze ridership data at finer levels of detail, greater timeliness and responsiveness, and lower cost. These do not accrue automatically; the most successful agencies have updated internal databases and adapted procedures to maximize the benefits offered by advanced technologies.

There is no one perfect solution. Agencies must consider their need for and uses of ridership data before deciding how best to proceed. Each ridership counting technology is appropriate to use for certain purposes, and there are successful examples of each in the case studies. Many agencies using manual techniques are satisfied with established data collection schedules and have been successful in meeting the needs of data users. One hundred percent accuracy does not exist with any technology. New passenger counting technologies have a break-in period of approximately 18 months during which start-up problems are identified and solved.

It is interesting to consider the adoption of new passenger counting technologies within the transit industry in the broader context of the spread of any new technology in any industry. A few innovators first implement new technologies when they became available, because these agencies immediately grasp the benefits to their operation. These are followed by early adopters, agencies that pay close attention to industry trends and see that the potential benefits of these new technologies are being realized. Late adopters, always the largest group, follow trends in technology once they are well established. Traditionalists, the fourth and final group in this typology, continue to observe the old ways of doing things long after new technologies are proven.

The transit industry appears to be in the latter stages of early adoption. New technologies and procedures can significantly increase the timeliness, quality, and quantity of ridership data available to an agency, enabling it to be more responsive to special requests and queries. Time invested in the early stages of use of new technologies to ensure that the agency's house is in order is generally considered to be well spent, and results in smooth data collection and analysis procedures once the initial bugs have been worked out. Nearly every agency surveyed reports that new passenger counting technologies are at least under active consideration, and many indicate plans to purchase in the near future. New developments and refinements in passenger counting technologies, along with the integration of the passenger counting function in ITS applications, suggest that the field will continue to evolve rapidly over the next decade.

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APPENDIX A

Survey Questionnaire and Responses

The number of responses does not always equal the total number of respondents, because many questions had the possibility of multiple answers. The number of responses is listed first, followed by the percentage of total respondents. Averages, medians and ranges are reported for numerical questions. Responses to open-ended questions were summarized into logical categories. A number next to an answer in the "Other" category indicates that more than one transit agency listed this response; if there is no number, the response was mentioned once.

Number of Buses

Average:	775
Median:	600
Range:	46 - 2,155

PURPOSES

Question 1. What purposes are ridership data collected and used for in your agency?

Track system-wide ridership totals	28	85%
Compile ridership by route	32	97%
Compile ridership by trip	30	91%
Compile ridership by route segment	26	79%
Compile boardings/alightings by stop	28	85%
Compile ridership by day-type and time period	27	82%
Monitor passenger loads at max load point	28	85%
Monitor schedule adherence	24	73%
Analyze origin-destination patterns	12	36%
Other	6	18%

Other includes running time, screenline counts, Section 15, boardings by fare media and operator compliance.

Question 2. Do you use this data to:

Calculate performance measures	30	91%
Add or delete trips	31	94%
Adjust running times	27	82%
Revise (change, continue or add) routes	31	94%

Assess changes in ridership	32	97%
Determine locations for bus shelters	26	79%
Accomplish other purposes	10	30%

Other purposes include Section 15 (2), forecast ridership/rider changes (2), transit priority, bus movements/delay, bus stops, marketing, adjust equipment to match ridership, improve operator accuracy.

Question 3. How does your agency define and count riders?

Linked trip	0	0%
Unlinked trip	19	58%
Both linked and unlinked trips	14	42%

Purposes for linked and unlinked trips include:

- Linked for revenue passengers, unlinked for total boardings (6)
- Unspecified (4)
- Linked for total ridership, unlinked unspecified
- Linked for transfer ratio/mode split, unlinked for boardings
- Linked for fare-related, unlinked for system utilization
- Comparison to calculate transfer use

TECHNOLOGIES AND PROCEDURES

Question 4. How often do you count and summarize ridership at the following levels:

System Level			
Daily	17	52%	
Periodically	13	39%	
Monthly		11	33%
Biannually		1	3%
Unspecified		1	3%
As Needed	1	3%	
No Response	2	6%	
Route Level			
Daily	9	27%	
Periodically	22	67%	

Monthly		7	21%
Quarterly		8	24%
Biannually		1	3%
Annually		2	6%
Less than once a year		4	12%
As Needed	2	6%	

Trip Level

Daily	3	9%	
Periodically	17	52%	
Monthly		1	3%
Quarterly		8	24%
Annually		3	9%
Less than once a year		5	15%
As Needed	13	39%	

Route Segment Level

Periodically	13	39%	
Monthly		1	3%
Quarterly		3	9%
Annually		4	12%
Less than once a year		5	15%
As Needed	16	48%	
No Response	4	12%	

Stop Ons/Offs

Periodically	13	39%	
Monthly		1	3%
Quarterly		3	9%
Annually		4	12%
Less than once a year		5	15%
As Needed	18	55%	
No Response	2	6%	

Maximum Load Points

Daily	1	3%

Periodically	18	*55%*	
Monthly		1	3%
Quarterly		11	33%
Annually		2	6%
Less than once a year		2	6%
Unspecified		2	6%
As Needed	12	36%	
No Response	2	6%	

Question 5. **If you conduct detailed counts and analysis at the route, stop or segment level for service planning or scheduling purposes, how often is ridership on any given route counted and analyzed for:**

Weekdays

Daily	2	6%
Monthly	4	12%
Quarterly	9	27%
Biannually	1	3%
Annually	5	15%
Every 1-2 years	4	12%
Every 2+ years	6	18%
As needed/no fixed schedule	1	3%
No response	1	3%

Saturdays

Daily	2	6%
Monthly	2	6%
Quarterly	6	18%
Biannually	5	15%
Annually	2	6%
Every 1-2 years	0	0%
Every 2+ years	6	18%
As needed/no fixed schedule	9	27%
No response	1	3%

Sundays

Daily	2	6%
Monthly	2	6%
Quarterly	5	15%
Biannually	5	15%
Annually	1	3%
Every 1-2 years	0	0%
Every 2+ years	6	18%
As needed/no fixed schedule	10	30%
No response	2	6%

Question 6. Do you conduct complete 100 percent ridership counts or do you use some sort of sampling plan?

System Level		
100% Count	14	42%
Factored from Revenue	16	48%
Sample	0	0%
Combination	2	6%
Not Specified	1	3%
Route Level		
100% Count	20	61%
Factored from Revenue	5	15%
Sample	5	15%
Combination	1	3%
Not Specified	2	6%
Trip Level		
100% Count	21	64%
Factored from Revenue	1	3%
Sample	10	30%
Combination	1	3%
Not Specified	0	0%
Route Segment Level		
100% Count	17	52%

Factored from Revenue	1	3%
Sample	10	30%
Combination	1	3%
Not Specified	4	12%
Stop Ons/Offs		
100% Count	19	58%
Factored from Revenue	0	0%
Sample	10	30%
Combination	2	6%
Not Specified	2	6%

Question 7. If you indicated use of a factored or sampling method in Question 6, please describe the factors used and/or your sampling plan and data expansion techniques.

Expand by fare payment type	5	15%
Derive ridership using average fare	4	12%
Each trip three times	4	12%
Each trip once	2	6%
Other	8	24%

Other includes APC-related, typical day, random sample, adjust farebox data by means of a sample survey, FTA cost revenue basis, Section 15-related, monthly average of farebox data, and econometric model.

Question 8. How do you collect ridership data?

Manually, estimating ridership from passenger revenue	13	39%
Manually, via vehicle operator trip cards	14	42%
Manually, using traffic checkers, pencil and paper	23	70%
Manually, using traffic checkers and hand-held units	12	36%
Manually, via on-board surveys	15	45%
Via electronic registering fareboxes	23	70%
Via smart cards	2	6%
Via automatic passenger counting (in use)	8	24%
Via automatic passenger counting (testing)	5	15%

Question 9. **If your agency uses more than one technique for collecting ridership data, please indicate the purposes each technique is used for.**

Manually, estimating ridership from passenger revenue

General purposes	1	8% of 13 systems using this technique
System ridership	7	54%
Special purposes only	2	15%
Other/unspecified	3	23%

Manually, via vehicle operator trip cards

General purposes	3	21% of 14 systems using this technique
System ridership	1	7%
Route ridership	2	14%
Trip ridership	1	7%
Special purposes only	6	43%
Other/unspecified	1	7%

Manually, using traffic checkers, pencil and paper

General purposes	13	57% of 23 systems using this technique
Trip ridership	1	4%
Special purposes only	6	26%
Other/unspecified	5	23%

Manually, using traffic checkers and hand-held units

General purposes	7	54% of 13 systems using this technique
Route ridership	2	15%
Trip ridership	1	8%
Loads	1	8%
Schedule adherence	1	8%
Special purposes only	1	8%
Other/unspecified	3	23%

Manually, via on-board surveys

System ridership	1	7% of 15 systems using this technique
Loads	1	7%
Schedule adherence	1	7%

Special purposes only	1	7%
Rider profile/market research	4	27%
Ridership by fare type	2	13%
Other/unspecified	6	40%

Via electronic registering fareboxes

General purposes	3	13% of 23 systems using this technique
System ridership	16	70%
Route ridership	8	35%
Trip ridership	3	13%
Ridership by fare type	2	9%
Other/unspecified	2	9%
Use, but not reliable	2	9%

Via smart cards

Rail only	1	50% of 2 systems using this technique
Currently testing	1	50%

Via automatic passenger counting (in use)

General purposes	5	63% of 8 systems using this technique
System ridership	1	13%
Route ridership	2	25%
Trip ridership	1	13%

Via automatic passenger counting (currently testing) 5 systems

PROCESSING AND REPORTING

Question 10. How does your agency input ridership data?

Manual data input	19	58%
Paper input via Optical Character Reader	2	6%
Hand-held data transmitted via physical connection to host computer	8	24%
Hand-held data transmitted remotely	7	21%
Direct downlink (probe) of electronic fare collection data	20	61%
Retrieval of electronic fare collection data at garage without physical connection	4	12%

Dynamic or periodic remote retrieval of electronic fare collection data	2	6%
Direct downlink (probe) of APC data	2	6%
Retrieval of APC data at garage without physical connection	4	12%
Dynamic or periodic remote retrieval of APC data	2	6%

Question 11. Please describe what steps are taken to edit and validate ridership data.

Compare ridership and revenue totals	20	61%
Compare with previously collected route-level data	24	73%
Look for unexplained variations across trips	19	58%
Compare daily ridership totals (if counts are taken on more than one day)	13	39%
Rely on the professional judgment of planners/schedulers	21	64%
Other	6	18%

Other includes use of thresholds, driver observations, compare ons/offs by trip, compare APC with manual counts, check that data are collected on "normal" days, and compare to other data in the same time period

Question 12. What types of reports are routinely generated from ridership data? Please also indicate approximately how often each type of report is prepared.

System ridership		
from farebox/trip cards	24	73%
from boarding/alighting data	3	9%
from both	1	3%
not specified	3	9%
Daily report	8	26% of 31 systems preparing this report
Monthly report	16	52%
Quarterly report	2	6%
Biannual report	1	3%
Annual report	1	3%
Not specified	3	10%
Route ridership		
from farebox/trip cards	15	46%
from boarding/alighting data	14	42%

from both	1	3%
not specified	2	6%
Daily report	4	13% of 32 systems preparing this report
Monthly report	11	34%
Quarterly report	6	19%
Biannual report	1	3%
Annual report	2	6%
Less frequently/as needed	6	19%
Not specified	2	6%
Route segment ridership from farebox/trip cards	1	3%
from boarding/alighting data	20	61%
from both	2	6%
Quarterly report	4	17% of 23 systems preparing this report
Biannual report	2	9%
Annual report	3	13%
Less frequently/as needed	13	57%
Not specified	1	4%
Stop-level boardings/alightings		
from boarding/alighting data	24	73%
from both	2	6%
Monthly report	2	8% of 26 systems preparing this report
Quarterly report	3	12%
Biannual report	1	4%
Annual report	6	23%
Less frequently/as needed	13	50%
Not specified 1 4%		
Performance measures		
from farebox/trip cards	11	33%
from boarding/alighting data	12	36%

from both	4	12%
Not specified	1	3%
Daily report	1	4% of 28 systems preparing this report
Monthly report	8	29%
Quarterly report	4	14%
Biannual report	1	4%
Annual report	4	14%
Less frequently/as needed	8	29%
Not specified	2	7%
Schedule adherence		
from farebox/trip cards	2	6%
from boarding/alighting data	15	45%
from both	1	3%
other/not specified	5	15%
Monthly report	5	22% of 23 systems preparing this report
Quarterly report	4	17%
Biannual report	2	9%
Annual report	2	9%
Less frequently/as needed	8	35%
Not specified	2	9%
Other		
from farebox/trip cards	1	3%
from boarding/alighting data	4	12%
Monthly report	2	40% of 5 systems preparing other reports
Annual report	1	20%
Less frequently/as needed	2	40%

Other reports include Section 15 (2), running times, running time utilization, transfers, schedule adherence, and activity center checks

Question 13. How did your agency develop data processing and report generation software?

In-house, by MIS or computer services department	20	61%
In-house, by end users of data	12	36%
Through the hardware vendor	11	33%
Through another outside vendor	14	42%
Through in-house department staff	3	9%
No response	1	3%

Question 14. If software was developed through an outside vendor, did the process include customization or modification of the software?

Yes, considerable	12	67% of 18 systems using the hardware vendor or an outside vendor
Yes, moderate	3	17%
Yes, minor	2	11%
No	1	6%

Question 15. Does your agency have the capability of generating ad hoc, specialized ridership reports?

Yes, through MIS or computer services department	15	45%
Yes, directly by end users	21	64%
Yes, through the outside vendor	6	18%
Through in-house department staff	3	9%
No	2	6%

ORGANIZATION

Question 16. Within your agency, which organizational unit is responsible for the following aspects of ridership data collection?

Overall Methodology		
Budget/Finance	11	33%
Planning	23	70%
Scheduling	19	58%
Computer Services/MIS	5	15%
Other	6	18%

Other includes Analysis/Research/Customer Services (4) and APC Manager/User IS Group (2)

Selection of Data to be Collected

Budget/Finance	5	15%
Planning	26	79%
Scheduling	22	67%
Computer Services/MIS	1	3%
Other	5	15%

Other includes Analysis/Research/Customer Services (4) and APC Manager/User IS Group

System Set-Up and Implementation

Budget/Finance	6	18%
Planning	19	58%
Scheduling	12	36%
Computer Services/MIS	14	42%
Other	7	21%

Other includes Analysis/Research/Customer Services (4), APC Manager/User IS Group (2) and Operations

Day-to-Day Management

Budget/Finance	8	24%
Planning	19	58%
Scheduling	13	39%
Computer Services/MIS	4	12%

Other 7 21%

Other includes Analysis/Research/Customer Services (4), APC Manager/User IS Group (2) and Maintenance

Question 17. Which organizational units use the ridership data?

At the system level

Budget/Finance	30	91%
Planning	25	76%
Scheduling	10	30%
Computer Services/MIS	1	3%

Other	12	36%

Other includes Marketing/Government Relations (6), Analysis/Research/Customer Services (4), Executive Office/Senior Management (4), Operations (2) and the State

At the route level

Budget/Finance	5	15%
Planning	31	94%
Scheduling	28	85%
Computer Services/MIS	1	3%
Other	10	30%

Other includes Marketing/Government Relations (5), Analysis/Research/Customer Services (3), Operations (3), and Executive Office/Senior Management (3)

At the trip level

Planning	30	91%
Scheduling	30	91%
Other	5	15%

Other includes Analysis/Research/Customer Services (3), Operations (3), and Legal/Workers Compensation

At the route segment level

Planning	27	82%
Scheduling	26	79%
Other	4	12%

Other includes Analysis/Research/Customer Services (3) and Operations (2)

At the bus stop level

Planning	25	76%
Scheduling	20	61%
Computer Services/MIS	2	6%
Other	10	30%

Other includes Operations (4), Analysis/Research/Customer Services (4), Marketing/Public Affairs (2) and Maintenance

Question 18. **If the data users are different from those responsible for the data collection process, please describe briefly the interaction between the two groups and any synergy or problems that arise as a result of the separation of these functions.**

Clarification of Responsibilities	7	42% of 17 systems responding to this question
Communications	4	24%
Data Issues	3	18%
Priority	2	12%
No problem	2	12%

RESOURCE REQUIREMENTS

Question 19. **How many staff (in terms of full-time equivalents) are assigned to carry out your agency's passenger counting program?**

Managers/Professionals

Average 2.22 Median 1

by data collection technology

Manual Average	2.31	Median 1
Hand Held Average	2.33	Median 2.5
ERF Average	2.28	Median 1
APC Average	2.34	Median 1

Support (i.e., equipment maintenance staff)

Average 1.25 Median 0

by data collection technology

Manual Average	1.81	Median 0
Hand Held Average	0.58	Median 0
ERF Average	1.93	Median 0
APC Average	0.94	Median I

Clerical

Average 1.28 Median 1

by data collection technology

Manual Average	1.41	Median 1
Hand Held Average	1.67	Median 1.5
ERF Average	1.65	Median 1
APC Average	0.27	Median 0

Traffic Checkers

Average 8.59 Median 4

by data collection technology

Manual Average	10.88	Median 7
Hand Held Average	12.33	Median 5.5
ERF Average	9.33	Median 8
APC Average	1.50	Median 0

Other

Average 0.55 Median 0

by data collection technology

Manual Average	0.75	Median 0
Hand Held Average	0.83	Median 0
ERF Average	0.47	Median 0
APC Average	0.06	Median 0

Total

Average 13.89 Median 7

by data collection technology

Manual Average	17.15	Median 10.5
Hand Held Average	17.75	Median 9
ERF Average	15.67	Median 12
APC Average	5.11	Median 4

Question 20. **What is the cost associated with your agency's passenger counting technology and program? Please report capital, operating, and maintenance costs separately. For capital costs, list actual purchase cost and year purchased. If**

you reported more than one technique in Question 8, please categorize costs accordingly. If you have more than one type of equipment, please itemize by equipment type.

Capital Cost:

Average	$1,765,844	Median $	763,000	21 systems reporting

by data collection technology

Manual Average	$26,150	Median	$26,150	1 system reporting
Hand Held Average	$44,640	Median	$48,000	5 systems reporting
ERF Average	$1,711,219	Median	$1,400,000	7 systems reporting
APC Average	$2,435,483	Median	$606,500	10 systems reporting

Operating Cost:

Average	$516,424	Median	$175,000	16 systems

by data collection technology

Manual/Hand Held Average	$806,087	Median	$650,000	9 systems
ERF Average	$286,667	Median	$150,000	3 systems
APC Average	$158,000	Median	$90,000	6 systems

Maintenance Cost:

Average	$49,572	Median	$25,000	13 systems

by data collection technology

Manual Average	$13,918	Median	$16,918	2 systems
Hand Held Average	$32,925	Median	$13,600	4 systems
ERF Average	$105,000	Median	$105,000	2 systems
APC Average	$54,980	Median	$75,000	5 systems

Question 21. **As a result of changing to a more automated data collection technology, was there any change in skill levels required by staff to implement the new system? If so, please describe briefly.**

Learn software/computer skills	7	64% of 11 systems responding to this question
Analytical skills	3	27%

Access GFI farebox data	3	27%
Other	3	27%
No Change	2	19%

Other includes hardware maintenance, system development and unspecified skills

Question 22. **As a result of changing to a more automated data collection technology, were there any headcount reductions or additions? If so, please estimate the number of positions affected.**

Traffic checkers/clerical	6 systems 50% of 12 systems responding to this question -10 positions (average)
MIS/Programmers	3 systems 25% +1 position (average)
Supervisors	2 systems 17% -1 position (average)
Technicians	1 system 8% +2 positions (average)
No Change	4 systems 33%
Prior cutbacks led to data collection enhancement 1 system 8%	

AGENCIES COLLECTING RIDERSHIP DATA MANUALLY

Question 23. **Has your agency considered investing in any data collection technologies to count ridership?**

Convert from paper/pencil to hand-held units	17	74% of 23 systems responding
Electronic fare collection (fareboxes and/or smart cards)	11	48%
APC	16	70%
Other	0	0%
Not considered	1	4%

Question 24. **If any of these options were considered and rejected, please indicate the reasons for this decision.**

Cost	4	44% of 9 systems responding to this question

Other technologies have priority	3	27%
Accuracy concerns	2	18%
Marginal usefulness	2	18%
Lack of personnel	1	9%

Question 25. **What is the current status regarding agency investment in passenger counting technologies?**

Plan to purchase	12	52% of 23 systems responding to this question
APC	7	
Additional APC units	2	
Hand-held units	2	
Unspecified	2	
Still being decided	9	39%
Considered, but rejected	1	4%
Has not been considered	1	4%

Question 26. **What sort of information regarding these technologies has been or would be of greatest use to your agency?**

Inventory of vendors/technologies available	5	42% of 12 systems responding to this question
Ability to duplicate/improve data collection	4	33% Experience elsewhere 4 33%
Integration with fare structure/other components	2	17%
Other	3	25%

Other includes equipment reliability, data management issues, maintenance cost

Question 27. **Please rate the usefulness of current manual techniques on a scale of 1 to 5, with 1 being least useful and 5 being most useful, in terms of collecting ridership data:**

Averages:

At the system level	2.05
At the route level	3.63
At the trip level	4.21
At the route segment level	4.44

At the stop level	4.21

Question 28. **What have been the major problems encountered with manual collection techniques?**

Accuracy	7	39% of 18 systems responding to this question
Time-consuming	7	39%
Absenteeism/missed data	6	33%
Limited resources/cost	6	33%
Labor intensive/labor issues	4	22%
Off peak/weekend data collection	3	17%
Correct stop list/preparing data sheets	2	11%

AGENCIES WITH ELECTRONIC REGISTERING FAREBOXES

Question 29. **How many buses and what percentage of your fleet are equipped with electronic registering fareboxes?**

Average number of buses	730
Average percentage of bus fleet	100%

Question 30. **Please indicate the type of farebox and other hardware/software options.**

GFI	16	70% of 23 systems responding to this question
Cubic	2	9%
GFI hardware/Cubic software	1	4%
Duncan Faretronic	1	4%
Unspecified	3	13%

Question 31. **How are ridership data accumulated?**

Bus block or run assignment	10	43% of 23 systems responding
Operator run assignment	5	22%
Operator run assignment with route segmentation	5	22%
Operator run assignment with route and trip segmentation	9	39%

Question 32. How satisfied have you been with the performance of this equipment in terms of counting passengers?

Very satisfied	5	22%
Satisfied	11	48%
Dissatisfied	6	26%
Very dissatisfied	0	0%
Neutral	1	4%

Average (1 = very dissatisfied, 4 = very satisfied) = 2.93

Question 33. Most new technologies require an implementation or "debugging" period in which operators become familiar with the new equipment and start-up problems are addressed. How long did this period last at your agency?

Average = 17.42 months

Question 34. What have been the primary benefits of the fareboxes for the agency?

Improved accuracy/reliability/access to data	9	43% of 21 systems responding to this question
Ridership by route, block, and trip	8	38%
More data; more detailed data	7	33%
Ridership by fare category	5	24%
Improved accountability/revenue control	5	24%
Systemwide ridership	4	19%

Question 35. What have been the major problems encountered with the fareboxes?

Currency jams/equipment problems	12	60% of 20 systems responding to this question
Operator compliance/attitude	8	40%
Software problems/limited data manipulation	5	25%
Accuracy	4	20%
Other	4	20%
No problems	3	15%

Other includes vendor cooperation, cost to maintain, maintaining revenue security procedures, and lack of integration with other on-board systems.

Question 36. Do you check the accuracy of farebox data? If so, please explain how farebox data are verified.

Compare with revenue	6	32% of 19 systems responding to this question
Compare with manual counts	4	21%
Random checks and counts	2	11%
Other	3	16%
No verification	3	16%

Other includes check against past counts, verify on an exception basis only, and compare with APC

Question 37. Please rate the usefulness of the fareboxes on a scale of 1 to 5, with 1 being least useful and 5 being most useful, in terms of collecting ridership data:

Averages:

At the system level	4.33
At the route level	3.81
At the trip level	2.60
At the route segment level	1.06
At the stop level	1.00

Question 38. What advice would you offer to other agencies interested in using electronic registering fareboxes to collect ridership data?

Comprehensive, ongoing training for drivers	6	35% of 17 systems responding to this question
Develop internal programs to analyze data	6	35%
Ensure that it can handle your fare structure	4	24%
Identify specific responsibilities	3	18%
Test often for accuracy	3	18%
Wait for new technology to be proven	2	12%
Work with manufacturers/software vendors	2	12%
Frequent preventive maintenance	2	12%
Very worthwhile for trip/system level data	2	12%
Understand reporting capabilities	2	12%
Ensure large memory or transmit data via radio	1	6%

AGENCIES WITH SMART CARDS

Question 39. **How many buses and what percentage of your fleet are equipped with smart card technology?**

Average number of buses	13
Average percentage of bus fleet	27.1%

Question 40. **How satisfied have you been with the performance of this equipment in terms of counting passengers?**

Satisfied	1

Question 41. **Most new technologies require an implementation or "debugging" period in which operators become familiar with the new equipment and start-up problems are addressed. How long did this period last at your agency?**

6-18 months (two responses)

Question 42. **What have been the primary benefits of smart cards for the agency?**

Demo only, but great experience	1
Section 15 data collection	1

Question 43. **What have been the major problems encountered with smart cards?**

Software bugs/software integration	2
Equipment problems	2
Training re data retrieval	1

Question 44. **Do you check the accuracy of smart card data? If so, please explain how smart card data are verified.**

Compare to manual counts	1
Customer interaction	1
No verification yet	1

Question 45. **Please rate the usefulness of smart cards on a scale of 1 to 5, with 1 being least useful and 5 being most useful, in terms of collecting ridership data:**

Only one response:

At the system level	2.0
At the route level	2.0
At the trip level	2.0
At the route segment level	1.0
At the stop level	1.0

Note: Low ratings on usefulness are closely related to the fact that the number of smart card users is very limited at this time.

Question 46. **What advice would you offer to other agencies interested in using smart cards to collect ridership data?**

Be very deliberate as the system is designed
Get the support of the Maintenance Dept.
Work with bus operators to gain their cooperation
Don't believe anyone who tells you it's simple
Research the time investment required in training and in retrieving/formatting data

AGENCIES USING APC

Question 47. **How many buses and what percentage of your fleet are equipped with APC units?**

Average number of buses	51
Average percentage of bus fleet	6.8%
Average percentage for non-demonstration agencies	9.2%

Question 48. **Who manufactures your agency's APC system (Hardware and Software)?**

UTA	4	33% of 13 systems with APCs	Both
Microtronix	2	17%	hardware only
Red Pine	2	17%	one hardware only, one both
Wardrop	2	17%	one software only, one both

Internal development	2	7%	software only
Others	5	33%	

Others include Echelon (both) Mafia (hardware), IRL (hardware), Pachera (hardware), SWI Systemware (software)

Question 49. How are passenger boardings/alightings counted?

Infrared beam	7	54% of 13 systems with APCs
Treadle mats	6	46%

Question 50. How is location ascertained?

Signposts	6	46% of 13 systems with APCs
Global Positioning System (GPS)	4	31%
Differential GPS	1	8%
Other	2	15%

Other includes signpost/GPS, mileage off bus transmission

Question 51. How satisfied have you been with the performance of this equipment in terms of counting passengers?

Very satisfied	4	36% of 11 systems responding to this question
Satisfied	7	64%
Dissatisfied	0	0%
Very dissatisfied	0	0%

Average (1 = very dissatisfied, 4 = very satisfied): 3.36

Question 52. Most new technologies require an implementation or "debugging" period in which operators become familiar with the new equipment and start-up problems are ironed out. How **long did this period last at your agency?**

Average: 16.9 months

Question 53. What have been the primary benefits of APC for the agency?

Detailed, more frequent data	9	75% of 12 systems responding to this question

Cost savings	4	33%
Other	4	33%

Other includes minimized turnaround/reporting time, understanding of what needs changing internally, Section 15 data collection, and electronic data transmission

Question 54. Have there been any problems encountered with the APC system?

Software development/maintenance/abilities	5	46% of 11 systems responding to this question
Maintenance/APC unit durability	4	36%
Signpost difficulties	3	27%
Data processing/manipulation time consuming	3	27%
User acceptance/priority within agency	3	27%
Other	3	27%

Other includes inability to equip all vehicle types within the fleet, incompatibility with operating procedures, and locational referencing problems in the absence of an AVL system

Question 55. Please rate the usefulness of the APC equipment on a scale of 1 to 5, with 1 being least useful and 5 being most useful, in terms of collecting ridership data:

Averages:

At the system level	2.82
At the route level	4.37
At the trip level	4.64
At the route segment level	4.27
At the stop level	4.09

Question 56. What proportion of raw data collected by APCs in you system is converted into data that can be used for service planning and scheduling?

Average: 74.4%

Question 57. What advice would you offer to other agencies interested in using APC equipment to collect ridership data?

Talk with and visit current users	5	36% of 12 systems responding
Evaluate adequacy of system database and upgrade	3	25%

Use GPS-based system	2	17%
Obtain strong management commitment	2	17%
Work within agency to establish priority for APC	2	17%
Other	5	36%

Other includes consider signpost system, be aware that extremes in passenger boardings may affect accuracy, integrate with AVL if possible, APCs are invaluable, and timely, thorough maintenance is critical.

APPENDIX B

List of Survey Respondents

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Technology Firms Interviewed

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