NATIONAL COOPERATIVE TRANSIT RESEARCH & DEVELOPMENT PROGRAM

16 Synthesis of Transit Practice

Collection and Application of Ridership Data on Rapid Transit Systems

TRANSPORTATION RESEARCH BOARD

National Research Council

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16 **Synthesis of Transit Practice**

Collection and Application of Ridership Data on Rapid Transit Systems

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NATIONAL COOPERATIVE TRANSIT RESEARCH & DEVELOPMENT PROGRAM

Administrators, engineers, and many others in the transit industry are faced with a multitude of complex problems that range between local, regional, and national in their prevalence. How they might be solved is open to a variety of approaches; however, it is an established fact that a highly effective approach to problems of widespread commonality is one in which operating agencies join cooperatively to support, both in financial and other participatory respects, systematic research that is well designed, practically oriented, and carried out by highly competent researchers. As problems grow rapidly in number and escalate in complexity, the value of an orderly, high-quality cooperative endeavor likewise escalates.

Recognizing this in light of the many needs of the transit industry at large, the Urban Mass Transportation Administration, U.S. Department of Transportation, got under way in 1980 the National Cooperative Transit Research & Development Program (NCTRP). This is an objective national program that provides a mechanism by which UMTA's principal client groups across the nation can join cooperatively in an attempt to solve near-term public transportation problems through applied research, development, test, and evaluation. The client groups thereby have a channel through which they can directly influence a portion of UMTA's annual activities in transit technology development and deployment. Although present funding of the NCTRP is entirely from UMTA's Section 6 funds, the planning leading to inception of the Program envisioned that UMTA's client groups would join ultimately in providing additional support, thereby enabling the Program to address a large number of problems each year.

The NCTRP operates by means of agreements between UMTA as the sponsor and (1) the National Research Council as the Primary Technical Contractor (PTC) responsible for administrative and technical services, (2) the American Public Transit Association, responsible for operation of a Technical Steering Group (TSG) comprised of representatives of transit operators, local government officials, State DOT officials, and officials from UMTA's Office of Technical Assistance, and (3) the Urban Consortium for Technology Initiatives/Public Technology, Inc., responsible for providing the local government officials for the Technical Steering Group.

Research Programs for the NCTRP are developed annually by the Technical Steering Group, which identifies key problems, ranks them in order of priority, and establishes programs of projects for UMTA approval. Once approved, they are referred to the National Research Council for acceptance and administration through the Transportation Research Board.

Research projects addressing the problems referred from UMTA are defined by panels of experts established by the Board to provide technical guidance and counsel in the problem areas. The projects are advertised widely for proposals, and qualified agencies are selected on the basis of research plans offering the greatest probabilities of success. The research is carried out by these agencies under contract to the National Research Council, and administration and surveillance of the contract work are the responsibilities of the National Research Council and Board.

The needs for transit research are many, and the National Cooperative Transit Research & Development Program is a mechanism for deriving timely solutions for transportation problems of mutual concern to many responsible groups. In doing so, the Program operates complementary to, rather than as a substitute for or duplicate of, other transit research programs.

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The members of the technical committee 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 committee, they are not necessarily those of the Transportation Research Board, the National Research Council, or the Urban Mass Transportation Administration, U.S. Department of Transportation.

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

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PREFACE

A vast storehouse of information exists on nearly every subject of concern to the transit industry. Much of this information has resulted from both research and the successful application of solutions to the problems faced by practitioners in their daily work. Because previously there has been no systematic means for compiling such useful information and making it available to the entire transit community, the Urban Mass Transportation Administration of the U.S. Department of Transportation has, through the mechanism of the National Cooperative Transit Research & Development Program, authorized the Transportation Research Board to undertake a series of studies to search out and synthesize useful knowledge from all available sources and to prepare documented reports on current practices in the subject areas of concern.

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 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 rail rapid transit agency managers and to those in the agency who are concerned with scheduling and operations planning, long range planning and design, financial planning, cost and subsidy allocation, performance analysis, and preparation of external reports. Information is presented on the passenger data collection methods and the use of passenger data by several rail rapid transit systems in North America.

Administrators, engineers, and researchers are continually faced with problems on which much information exists, either in the form of reports or in terms of undocumented experience and practice. Unfortunately, this information often is scattered and unevaluated, and, as a consequence, in seeking solutions, full information on what has been learned about a problem frequently 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 problem. In an effort to correct this situation, NCTRP Project 60-1, carried out by the Transportation Research Board as the research agency, has the objective of reporting on common transit problems and synthesizing available information. The synthesis reports from this endeavor constitute an NCTRP publication series in which various forms of relevant information are assembled into single, concise documents pertaining to specific problems or sets of closely related problems.

Ridership data collection includes passenger load counts, on-board counts, turnstile and faregate data tallies, station activity counts, origin-destination surveys, and fare surveys. The procedures used to collect and evaluate these data, including survey design, sampling design, management and training, and data entry and analysis are described. The uses of the data by the transit agencies surveyed are summarized. Newer rail rapid transit systems with automated fare collection equipment requiring fare control upon both entry and exit, can more easily provide passenger data than older rail rapid transit systems that typically collect ridership data manually. Many older systems are moving toward automated fare collection systems that will provide better data at a lower cost.

To develop this synthesis in a comprehensive manner and to ensure inclusion of significant knowledge, the Board analyzed available information assembled from numerous sources, including a large number of public transportation agencies. A topic panel of experts in the subject area was established to guide the researcher 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.

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Information on current practice was provided by many transit agencies. Their cooperation and assistance were most helpful.

COLLECTION AND APPLICATION OF RIDERSHIP DATA ON RAPID TRANSIT SYSTEMS

SUMMARY

The role of rail rapid transit is to carry people. Ridership data describing the movement of passengers and monitoring passenger-carrying performance is essential to proper rapid transit operation. A large amount of such data is being collected for a broad array of uses including scheduling and operations planning, longer range planning and design, financial planning, cost and subsidy allocation, performance analysis, preparation of external reports including federally mandated statistics, and marketing evaluations.

The ridership data collection activities carried out to provide the necessary information include passenger load counts taken from station platforms, counts made on board trains, turnstile and faregate data tallies, various kinds of station activity counts, origin-destination surveys, and surveys focusing on fares. These data collection activities each involve field survey design, sampling design, survey management, training, quality control, data entry, analysis, and sometimes questionnaire design.

Rail rapid transit ridership data are being collected and applied without benefit of any current industry norm, standards, handbooks, or manuals. Operators are generally interested in improving individual aspects of the data collection and analysis process. Most report overall satisfaction with the data ultimately produced, but in many instances the results lack any meaningful statistical evaluation. Individual rail rapid transit operators do have established procedures, and most have taken innovative or improved approaches to at least some of their data collection needs. Techniques and approaches that are state of the practice for some operators offer potential for significant improvements for other operators.

There has been a perception that rail rapid transit is divided into two camps—"new" systems with fare control upon both entry and exit, requiring automated fare collection equipment, therefore offering passenger data automation capability; and "older" systems, with mechanical turnstiles and a corresponding need to collect all data manually. In fact, the "older" systems are fast moving toward automated fare collection systems that will shape passenger data collection for decades to come, a development which is occurring in the vacuum created by lack of industry standards.

Much of rail rapid transit passenger data collection and analysis remains labor intensive. Many of the older techniques are undoubtedly valid, but need examination to see if there are more cost effective and statistically valid approaches, or if enhancements could be obtained through even limited adjustments. A number of operators acknowledge elements of their data collection and processing activities that are due for overhaul, while other procedures are clearly state-of-the-art. There is much to be

learned from what individual operators have been able to accomplish with their own resources.

The linkages between data collection, data processing, and data application are inherently the weakest links in obtaining and using passenger data to enhance system operation. Ongoing vigilance is required to ensure that data collection is not treated as an end unto itself, but rather is keyed to the real information needs which exist. The most productive area for new applications has been found at the interface between the human data collector and automated data processing. Examples are optical scanning of field sheets and use of hand-held data entry devices to replace manual data entry.

Research needs include further analysis of rail rapid transit data uses and linkages between uses and data collection, development of standards and manuals including statistical procedures, priority specification of standards for passenger data acquisition in connection with automatic fare collection, development and exchange of ridership data analysis software, evaluation of passenger traffic simulation in connection with automatic fare collection, preparation of procedures and tools for meeting Urban Mass Transportation Administration Section 15 reporting requirements and internal passenger data needs concurrently, and promotion of exchange of information on ridership data collection and application developments.

CHAPTER ONE

INTRODUCTION

Passenger data collection on rapid transit systems takes place under widely varying circumstances. Some systems have fare structures that require monitoring each passenger upon exit, as well as upon entrance, offering at least the potential of using fare collection data to compute maximum passenger loads, incidence of transfers, trip length, and other information required for daily operation and reporting. On the majority of systems, fare collection takes place only upon entrance and provides only entering volumes. On no system does fare collection provide all of the ridership data needed. The gap is filled by various forms of typically labor-intensive field surveys on trains, on platforms, and in and around stations. The purpose of this synthesis is to provide a compendium covering the state of the practice in collection and application of ridership data on rapid transit systems, including alternative techniques, opportunities for increased cost effectiveness, and new developments.

IMPORTANCE OF PASSENGER DATA

The fundamental purpose of a rail rapid transit system is not the running of trains; it is to provide mobility by carrying people to and from their urban activities. Without data on the movement of people on a transit system, it is impossible to ensure that the system is properly accomplishing its purpose.

Ridership data provide information essential for deploying equipment and staff, scheduling trains, and planning improvements in a manner that allows for effective transportation service matched to the travel needs of its riders. Passenger data relate directly to revenue data, and allow financial planning and allocations of revenues and costs among participating operators or jurisdictions. These data are an essential element of monitoring operator performance, for both internal use and for reporting performance to other interested parties. Passengers and prospective passengers constitute the market for rail rapid transit service, thus ridership data must be the cornerstone of any market development program or investigation.

Table 1 illustrates the uses to which rail rapid transit operators put ridership data. It is developed from the survey of operators conducted for this synthesis. It shows the number of operators reporting each application of each type of ridership data. For example, it shows that nine out of 10 responding operators use passenger load counts for scheduling and operations planning. The one operator that does not, uses information derived from faregate tallies instead, so all responding operators use some form of ridership data for scheduling and operations planning.

In addition to all the surveyed rail rapid transit operators applying ridership data in scheduling and operations planning, most report using one or another form of ridership data in systems planning and design, in financial planning, in performance analysis, in the preparation of external reports, for revenue or cost allocation, and in marketing.

PROJECT SCOPE

The scope of this synthesis project is the collation, presentation, and interpretation of information on all aspects of obtaining and applying ridership data on rapid transit systems. It has included a survey of rapid transit systems in North America to ascertain how each collects and uses ridership data. Included are the different categories of data uses listed down the left hand column of Table 1, and the different types of data collection listed across the top.

This synthesis focuses on the special passenger data needs and conditions of rail rapid transit, which is the operation of high speed, electrically powered passenger rail cars operating in trains in underground tunnels, on elevated lines, or other exclusive urban rights-of-way, stopping at stations with high platforms and fare control. One out of four public transit trips in North America today is made on rail rapid transit, exclusive of other rail transit modes such as light rail or commuter rail.

A number of ridership data collection and application concerns are common to both bus and rail systems, and the procedures and analyses involved are similar. To that extent, the material in this synthesis and in works on bus ridership data collection have applications in common. Other concerns and solutions are unique to the rail rapid transit environment, because of its high passenger loadings, multiple car trains, and use of station fare collection.

Each passenger data use is identified in context with the particular surveys or counts employed to obtain the data. For each type of survey a discussion is provided of field survey design, sampling design, management and personnel requirements, training and quality control, data entry and analysis, and data reliability, adequacy and cost. Classifications by passenger type, time of day, trip type, fare type, and origin-destination are addressed. The state of the art and future directions are covered, including techniques, hardware technology, associated software, and recommended research.

It must be understood, however, that a brief synthesis cannot convey the detail which may reside in source documentation. In particular, most software is identified as to purpose without detailed description, for reasons of both paucity of information and complexity of documentation available. This synthesis will function primarily as an identifier of promising approaches to data collection and application, serving as a starting point for transit professionals wishing to consider and evaluate alternative methods and enhancements.

METHODOLOGY

The primary source of data for this synthesis has been rapid transit operators. Some information comes from established liter-

TABLE 1

NUMBER OF OPERATORS REPORTING EACH APPLICATION OF EACH TYPE OF RIDERSHIP DATA

Uses of Ridership Data	Types of Rapid Transit System Ridership Data Collection Activities								
	Passenger Load Counts	On-Board Checks	Turnstile/ Fare Gate Tallies	Station Activity Counts (1)	Station-to-Station Surveys (2)	O-D Surveys (3)	Fare Surveys	Performance Surveys (4)	All Types Combined (5)
Scheduling & Operations Planning	9	5	8	5	2	6	3	1	10
Longer Range Planning & Design	5	2	7	6	2	4	3		9
Financial Planning	1	1	9	3	1	2	5		9
Cost/Subsidy Allocation			4	2		2	4		5
Performance Analysis	5	3	6	5	1	2	2	3	9
External Reports	3	1	8	2	4	5	2	1	9
Marketing	1	1	3	2	1	4	3	1	6
Miscellaneous				3		1			3

(1) Includes boarding and alighting counts conducted at stations.
(2) Includes trip length and transfer surveys, but not origin-destination surveys.
(3) Origin-destination surveys.
(4) Primarily surveys of the passenger environment, such as condition of the physical plant, or illegal activity in stations. Not specifically inquired about in the synthesis survey.
(5) Out of 10 North American rail rapid transit operators responding.

ature sources, but these do not offer much on current rapid transit practices. Certain information was obtained in telephone inquiries to equipment and software vendors identified by rapid transit operators. This synthesis study has not included original research.

The information provided by the rapid transit operators was both in the form of reports produced by or for the operators, and in the form of answers to the synthesis survey. The reports and manuals furnished by operators are listed in Appendix A. Information not referenced in the text as being from the literature is from the survey of operators, the accompanying reports and manuals, or followup telephone inquiries. Each operator that responded to the written survey was contacted in July or August of 1991 to obtain updated information.

The survey of operators, or synthesis survey, was sent out in September 1989. It is reproduced here in Appendix B. The survey consisted of three parts, which were:

Form A: Systemwide Data Collection and Application Process Questionnaire
Form B: Count or Survey Description
Form C: Ridership Data Use Description

Survey recipients were requested to fill out Form A themselves, or have it filled out by their assistant. They were asked to have Form B filled out by the appropriate persons involved in each type of ridership data collection, and to have Form C filled out by the persons involved in each type of ridership data application. By this means it was hoped to obtain the possibly different perspectives of those who administer data collection and those who use the data collection results.

The synthesis survey was sent to rail rapid transit operators in the United States and Canada. Light rail, commuter rail, and automated guideway transit were excluded. The surveys returned cover 10 of the primary operators in the 12 metropolitan areas with conventional rail rapid transit. Table 2 lists the responding operators, gives initials used for identification, and provides fleet and ridership data to indicate relative size.

The returned surveys provide extensive detail and backup documentation in most instances; much more than can be in-

TABLE 2

RAIL RAPID TRANSIT OPERATORS COVERED BY THE SURVEY RETURNS

Operator	Acronym	Region	Department Reporting	Peak Vehicle Requirements	Annual Passengers
Bay Area Rapid Transit District	BART	San Francisco	Research and Analysis	346	64,100,000
Chicago Transit Authority	CTA	Chicago	Operations Planning	923	168,600,000
Greater Cleveland Regional Transit Authority	GCRTA	Cleveland	Planning	35	7,900,000
Massachusetts Bay Transportation Authority	MBTA	Boston	Planning	449	157,900,000
Metro-Dade Transit Agency	MDTA	Miami	Planning and Development	70	12,100,000
Metropolitan Atlanta Rapid Transit Authority	MARTA	Atlanta	Transit Research and Analysis	139	65,600,000
New York City Transit Authority	NYCTA	New York	Operations Planning: System Data and Traffic	5024	1,702,600,000
Southeastern Pennsylvania Transportation Authority	SEPTA	Philadelphia	Planning and Development	297	94,100,000
Toronto Transit Commission	TTC	Toronto	Administration and Planning	622	291,100,000
Washington Metropolitan Area Transit Authority	WMATA	Washington	Planning	576	183,500,000

Fleet and passenger data sources (1989 data): UMTA Section 15 Annual Report and American Public Transit Association. Annual passengers are reported as unlinked trips.

cluded within the confines of this synthesis. The synthesis is a distillation of the main points which emerged, along with tabulations of the information provided, and examples of surveys and applications reported. The selection of examples is designed to cover each type of survey encountered, to illustrate the range of methodologies and formats, and also to present what seemed to be the more notable surveys and applications in terms of completeness or state-of-the-art development.

CHAPTER TWO

USES OF RIDERSHIP DATA

Table 1 and the accompanying introductory discussion provide an overview of the breadth and importance of rail rapid transit ridership data applications. It is also instructive to take the perspective offered by exploring individual applications in more detail. Applications that are routine for one rail rapid transit operator may be for another operator a new and innovative use of data already collected for other purposes, or of data that could be cost-effectively obtained given the benefits to be derived.

The exploration of individual applications which follows is divided into five sections using the data use categories identified in Table 1, or pairings thereof. These five sections are scheduling and operations planning, longer-range planning and design, financial planning and cost/revenue allocation, performance analysis and external reports, and marketing and other applications. In each of the five sections is a tabular listing of individual data applications. For each individual operator, the department and/or section making use of the data is identified, the applications are given, and the types of data collection used as the source are indicated. The terminology used to describe type of data collection is a compromise, for consistency's sake, among the names given by the different operators.

The listings include only applications reported in the synthesis survey (Appendix B) or accompanying reports. It should be recognized that individual operators probably make use of ridership data in ways that did not come to mind in filling out the survey forms.

SCHEDULING AND OPERATIONS PLANNING

Table 3 lists the reported scheduling and operations planning uses of ridership data. The most universal application in this category is in determining the number of trains and number of cars per train necessary to accommodate passenger loadings. These determinations, along with concurrently obtained information on schedule adherence, are used to prepare schedule and "train consist" revisions if required.

For this application, the Bay Area Rapid Transit District (BART) develops 10-day average maximum loads for each train and day of week in the peak direction. Other operators, without equivalent automated data collection capabilities, use peak period maximum load point volumes on the survey day or days, broken down into 15-minute periods. The latter data format, often with 30-minute data breakouts outside of peak hours, is typical of what is used in many different scheduling and operations planning applications.

All properties obviously use passenger data in a monitoring function; checking train and car requirements is one aspect of monitoring. The Chicago Transit Authority (CTA) and the Metropolitan Atlanta Rapid Transit Authority (MARTA) explicitly highlight the monitoring function in their procedures. For example, CTA states that information is collected to review continuously the adequacy of service provided, enhancing service and facility improvement or adjustment recommendations as appropriate. MARTA's emphasis on monitoring is implicit in the title of their passenger data collection arm—the Service Monitoring Department.

The MARTA Scheduling Department, upon receiving ridership and service data from the Service Monitoring Department, produces one or several reports based on the nature of the investigation involved. Reports pertinent to the rail rapid transit operation include the "Rail Passenger Analysis" report, recording all rail trips at selected stations to determine passenger load information, and the "Load Factor Analysis" report, to determine individual trips that may exceed service standard load factors. Load factors are adopted by resolution of the MARTA Board, and the use of passenger data to adjust train consists and schedules to maintain service standards is of corresponding importance to MARTA.

The Massachusetts Bay Transportation Authority (MBTA) reports using passenger data to plan service and equipment utilization in both the short and intermediate range. Other responses imply both a short and intermediate range focus as well.

Scheduling of station personnel is another widespread use of ridership data in the realm of scheduling and operations planning. The New York City Transit Authority (NYCTA) is using ridership data to determine hours individual stations should be open, to evaluate economy measures affecting lightly used shuttles and nighttime services, to develop skip-stop and express service options, and to plan the service diversions required by track reconstruction projects. Ridership data are used to assess the impact on existing riders of service options, with numbers of riders affected being an important evaluation criterion.

LONGER RANGE PLANNING AND DESIGN

Table 4 lists the longer range planning and design uses of ridership data reported in the synthesis survey. Whereas uses of ridership data in scheduling and operations involve service planning and equipment utilization, uses in the longer range involve systems planning and design of new or rebuilt facilities. The one classification of data uses melds into the other, as illustrated by the BART example of using ridership data to plan new service arrangements with the opening of BART's third track through downtown Oakland.

BART also notes use of ridership data for other analyses related to track capacity, and for safety analyses. Their comprehensive data set allows train loads and/or boarding and alighting counts, simulated from entry/exit faregate data, to be averaged by scheduled train, by peak hour, by peak period cycle, or to be

TABLE 3

REPORTED USES OF RIDERSHIP DATA IN SCHEDULING AND OPERATIONS PLANNING

Operator	Department	Data Use	Source
BART	Field Services, Support and Analysis Division	Determine number of cars/train required and identify new service requirements	Entry/exit fare gate tallies (maximum load point simulation)
CTA	Operations Planning	Identify and determine service adjustment and facility improvement needs	Passenger load counts, station boarding/alighting counts, turnstile tallies
GCRTA	N/I	Scheduling and operations planning	Passenger load counts, turnstile/farebox tallies
MBTA	Planning Division - Scheduling Department	Determine number of cars/train and number of trains required	Passenger load counts, turnstile tallies
	Planning Division - Operations Planning Department	Plan service and equipment utilization (short and intermediate range)	Passenger load counts, station boarding/alighting and transfer counts, turnstile tallies, origin-destination surveys, fare surveys
MDTA	Operations Planning and Scheduling Division	Scheduling and operations planning	Passenger load counts, on-board checks, turnstile tallies
MARTA	Scheduling Department	Identify and determine service adjustment needs, plan extensions or revisions	Passenger load counts, on-board checks, personal observations
NYCTA	Operations Planning - Rapid Transit Schedules	Determine schedule adjustments needed	Passenger load counts
	Operations Planning - Rapid Service Planning	Evaluate service options, diversion planning for reconstruction projects	Passenger load counts, turnstile entry and exit tallies
		Evaluate service economy options	Passenger load counts, on-board checks, turnstile entry and exit tallies
		Determine hours individual stations should be open, prioritize station modernization	Turnstile entry and exit tallies
	Operations Planning - Staten Island Service Planning	Develop skip-stop and express service options	On-board checks
SEPTA	N/I	Scheduling and operations planning	Passenger load counts, on-board checks, turnstile tallies, special surveys
TTC	N/I	Scheduling and operations planning	Passenger load counts, station boarding/alighting counts, station mode of access counts, turnstile tallies
WMATA	Planning Department	Check passenger loads and schedule adherence, determine number of cars/train and number of trains required, make headway adjustments	Passenger load counts, origin-destination surveys

N/I = Not Indicated

itemized individually, for one or several stations by direction. All data are linked, and are averaged and summarized as needed to determine specifics of passenger flow averages and extremes. BART can simulate and test alternative service configurations in this manner.

MBTA conducted comprehensive boarding and alighting counts and transfer counts in 1989 for use in planning rapid transit improvements. The Toronto Transit Commission (TTC) reports using data on passenger mode of arrival at stations to develop design criteria, which will be employed in the design of future operations. TTC also uses these data in designing station access roadway improvements.

The most frequently reported use of ridership data in systems planning and design was planning for and prioritizing station renovations on older systems. Examples include an NYCTA study of the number of automatic fare collection turnstiles needed to convert fare collection from tokens to fare cards; station platform extension and station consolidation studies for NYCTA's Staten Island division; and the Greater Cleveland Regional Transit Authority's (GCRTA) use of ridership data to prioritize public address system installation. Planning for improvements to other rapid transit facilities and equipment also benefits from system usage data.

The Washington Metropolitan Area Transit Authority (WMATA) shares its ridership data with the Metropolitan Washington Council of Governments (MWCOG), the Washington, D.C. region's Metropolitan Planning Organization (MPO). Station, maximum load point and total ridership volumes are used in travel demand model validation, and origin-destination survey results are used in development of specific model compo-

TABLE 4

REPORTED USES OF RIDERSHIP DATA IN LONGER RANGE PLANNING AND DESIGN

Operator	Department	Data Use	Source
BART	Planning & Research	Long range train operations planning, other capacity analyses, safety analyses	Entry/exit fare gate tallies (train load and performance simulation)
CTA	Operations Planning	Systems planning and design	Passenger load counts, station boarding/alighting counts, turnstile tallies, sta.-to-sta. counts/surveys, origin-destination surveys, fare surveys
GCRTA	Operations Division	Prioritize stations for public address system improvements	Turnstile/farebox tallies
MBTA	Planning Division - Operations Planning, Service Planning	Long range planning of station renovations, facilities, equipment procurement	Passenger load counts, station boarding/alighting and transfer counts, turnstile tallies, origin-destination surveys, fare surveys
MDTA	Management Information Systems, Operations Planning	Systems planning and design	Station activity counts, origin-destination surveys, passenger load counts, station boarding/alighting and transfer counts, turnstile tallies
MARTA	Planning	Update regional forecasting model	On-board survey/ridership travel patterns
		Determine design capacity of rail stations	Forecasted data from regional model
		Design feeder bus system	Entry faregate tallies
		Determine priority for rail construction and expansion of new service	Entry faregate tallies and forecasted data from regional model
NYCTA	Operations Planning - Staten Island Service Planning	Station consolidation and platform extension studies	On-board checks
	Revenue Department - Automatic Fare Collection	Determine quantities of AFC turnstiles required for conversion to automatic fare collection	Turnstile entry and exit tallies
SEPTA	N/I	Systems planning and design	Passenger load counts, on-board checks, turnstile tallies, special surveys
TTC	N/I	Systems planning and design; including developing design criteria, planning station access improvements	Passenger load counts, station boarding/alighting counts, station mode of access counts, origin-destination surveys, fare surveys
WMATA	Planning Department	Various planning/marketing purposes including use by Metropolitan Planning Organization for demand modeling	Passenger load counts, fare gate tallies, origin-destination surveys

N/I = Not Indicated

nents. The demand models in turn are used for multimodal transportation planning throughout the region and for transit planning on WMATA's behalf. An example of a travel demand model component of direct interest to WMATA is the model for estimation of Metrorail passenger mode of access to stations.

FINANCIAL PLANNING AND COST/REVENUE ALLOCATION

The importance of passenger counting to revenue control should not be overlooked in considering the uses of ridership data with respect to financial matters. The synthesis survey did not ask about revenue control, only about financial planning and cost/revenue allocation. It can be assumed that revenue control is one of the basic uses of passenger counting.

The CTA, for example, points out that the passenger tallies contained in individual agent and conductor reports must match exactly the fares collected. NYCTA reports a major counting program as part of their effort to counter fare abuse. Approximately one quarter of NYCTA's traffic checking costs are currently allocated to fare evasion studies. Count data obtained on behalf of the fare abuse task force are used to deploy approximately 50 police and 100 uniformed property protection agents to some 300 critical fare control areas. Results from the monthly count cycle are used to adjust the police and property protection agent deployment strategies. NYCTA makes double use of its fare abuse study counts by employing them as well in operations planning and other applications.

Table 5 presents the reported uses of ridership data in financial planning and cost/revenue allocation, along with the types of data collection employed. The use of ridership data for making

TABLE 5

REPORTED USES OF RIDERSHIP DATA IN FINANCIAL PLANNING AND COST/REVENUE ALLOCATION

Operator	Department	Data Use	Source
BART	Planning & Research - Research & Analysis Division	Ridership/revenue projections for annual budget, 5-year plan	Entry/exit fare gate tallies and bus transfer count data
	Planning & Research	Determine BART/MUNI Fast Pass and BART Plus Ticket revenue reimbursement	Entry/exit fare gate tallies
CTA	Financial Reporting and Analysis, Strategic Planning, Operations Planning	Determine ridership, survey market for fare changes	Turnstile tallies, fare surveys
GCRTA	Planning & Revenue Departments	Financial planning	Turnstile/farebox tallies, on-board checks
MBTA	Planning Division, Revenue Department	Ridership/revenue projections for future budgets	Turnstile tallies, fare surveys
	Planning Division, Treasury	Allocate rail service costs to member communities	Turnstile tallies, station boarding/alighting counts, fare surveys
MDTA	Managment Information Systems	Ridership and revenue projections for annual budget and long range plans	Ridership counts from turnstiles, revenue reconciliation and pass revenue allocation
MARTA	Research and Analysis	Ridership/revenue projections for annual budget; 5 year plan	Entry faregate tallies and bus transer count data
NYCTA	Fare Abuse Task Force	Monitor fare abuse and develop strategies for police deployment and property protection	Turnstile entry and exit tallies, station activity counts
	Operations Planning - System Data and Traffic	Determine token booth wait and transaction times	Queuing count
SEPTA	Revenue Development - Accounting	Determine annual off-peak senior-citizen trips for PennDOT reimbursement	Off-peak senior-citizen counts (now superseded by automatic fare collection)
	N/I	Financial planning	Passenger load counts, on-board checks, turnstile tallies, special surveys
TTC	N/I	Financial planning and cost/revenue allocation; including determining concession rentals and average fare	Turnstile tallies, station entry counts, station boarding/alighting counts, fare surveys
WMATA	Planning Department, Rail Division	Determine system ridership, calculate average fare, allocate subsidy costs to member jurisdictions	Faregate tallies, origin-destination surveys

N/I = Not Indicated

ridership and revenue projections for future budgets is specifically reported by BART and MBTA, and is probably commonplace. Other operators listed the even more basic task of determining current system ridership as a financial planning application. This is an essential task that is undoubtedly universal in practice.

BART's Five Year Plan presents past ridership performance compared to past projections and future projections, and gauges future budget requirements accordingly. MBTA uses revenue-based ridership estimates to produce monthly ridership reports and variance from budget. CTA develops and uses traffic trends by fare category and day of the week.

Individual operators note financial planning use of ridership data for evaluating fare changes, calculating average fares, and monitoring token booth wait and transaction times. The latter application, initiated by NYCTA after a fare increase required more complex change making, provides information on the mean transaction time at a token booth, as well as the maximum, minimum, and average time that a passenger waits in line. TTC sets concession rentals on the basis of station activity counts.

Five operators report use of ridership data for cost/revenue allocation as an activity separate and distinct from reporting required for federal funding. These cost/revenue allocation applications range from allocation of joint revenues among operators to allocation of rail service costs among transit authority member jurisdictions. Until recently, the Southeastern Pennsylvania Transportation Authority (SEPTA) used special counts to quantify senior citizen off-peak ridership for purposes of state funded fare subsidy reimbursement, but a continuous record is now provided thanks to new automated fare collection equipment.

The allocation of joint revenues occurs between BART and connecting local transit systems. Two joint fare instruments require this allocation; the multi-ride joint fare "Fast Pass" and the "BART Plus" combined bus pass and stored-fare BART ticket. "Fast Pass" fare allocation, by way of example, employs an intricate formula requiring three measures obtained from BART's passenger data: systemwide BART ridership, intra-San Francisco BART ridership using standard BART fare cards, and intra-San Francisco BART ridership using the "Fast Pass." The MBTA provides an example of rail service cost allocation among transit authority member jurisdictions based in part on station boardings. One factor in the WMATA allocation of rail service costs is the percentage of riders from each contributing jurisdiction.

PERFORMANCE ANALYSIS AND EXTERNAL REPORTS

The reported uses of ridership data in performance analysis and external reports are tabulated in Table 6. Performance analysis in the context of operations monitoring takes place in connection with scheduling and operations planning applications, already discussed. For example, schedule adherence data gathered in connection with ridership data is used for monitoring on-time performance, and its analysis can lead to operating or schedule changes.

Other performance analysis applications include monitoring patronage, both systemwide and broken down by line or other categories of interest, and monitoring other measures calculated on a per ride basis, such as capital and operating cost, or accidents, per passenger trip. NYCTA monitors infractions of rules, such as illegal commercial activity in stations, to assist in deployment of enforcement.

One of the most interesting performance analysis applications is BART's "Performance Monitoring System," described more extensively in the "Entry/Exit Faregate Tallies" section of Chapter Three. With this system passenger delays are computed each day by time and location, allowing remedial action to be focused on service problem areas affecting the most riders to the greatest degree.

All U.S. rail rapid transit operators produce the external reporting mandated by Urban Mass Transportation Administration (UMTA) required under Section 15 of the Urban Mass Transportation Act. The passenger data requirements for urbanized areas of 200,000 population or more mandate reporting of unlinked passenger trips and passenger miles, by mode, in order to receive Section 3 and Section 9 funds. (An unlinked trip is a trip or portion of a trip made on a single line. A trip involving two lines, for example, is two unlinked trips or one linked trip. Rail rapid transit patronage data are normally reported in linked trip format, because almost all rail-to-rail transfers take place within the fare-paid areas of interchange stations, and thus are not counted with turnstiles or equivalent fare control. Accordingly, a rail-to-rail transfer count must be added to provide unlinked trip data.)

In addition, passenger miles are an input to the congressionally mandated apportionment formula for Section 9 assistance. UMTA, as of the summer of 1991, is moving to simplify these requirements. Comments have been received on proposed revisions, and writing of final regulations is in process. However, they must be approved by the Office of Management and Budget (OMB), and apportionment formulae are legislated, so the outcome cannot be forecast at this time.

Three operators report conducting surveys that are specially designed to meet Section 15 requirements for reporting passenger miles and unlinked trips. These surveys are described under "Station-to-Station Surveys" in Chapter Three. Passenger mile reporting requires trip length data, and unlinked trip reporting requires information on the number of rail rapid transit to rail rapid transit transfers made, in addition to readily available patronage totals. Operators that have a single rail rapid transit line can and do obtain the requisite data with on-board checks alone, since rail rapid transit to rail rapid transit transfers do not occur on such systems. Other operators that do not conduct special surveys must have an alternate data source such as BART's entry/exit faregate data or a satisfactory origin-destination survey.

UMTA does not specify the manner in which passenger miles and unlinked trips are to be obtained for rail rapid transit systems, only that the results must meet the statistical test of being within 10 percent at the 90 percent confidence level. Table 6 includes the data sources each operator uses to develop passenger miles and unlinked trips for Section 15 reporting.

Examples of external reports other than those required by UMTA include NYCTA's annual cordon count, which provides 24-hours worth of detailed information, with trends, on rapid transit and surface passengers and vehicles entering and leaving the Manhattan Central Business District (CBD). CTA likewise reports results of an annual cordon count, and TTC also indicates preparation of external reports.

MARKETING AND OTHER APPLICATIONS

Table 7 completes the listing of ridership data uses, and the corresponding types of data collection used, covering marketing and miscellaneous applications. The most common ridership data use identified in the marketing area is to obtain a better understanding of rail rapid transit ridership market components, with the objective, as stated succinctly by CTA, of increasing ridership. For example, BART combines patronage data and information on rider characteristics and travel habits to measure growth by market areas.

CTA has been placing emphasis on information related to developing new fare media, specifically magnetically encoded passes, and new approaches to structuring fares. They designed application-specific surveys to learn about the use of magnetically encoded passes, to identify quickly any problems with the fare media and mechanical equipment involved, to learn about how unlimited ride pass holders make use of the rail rapid transit system as compared to riders who do not buy passes, and to explore the response of individual market subgroups to possible fare changes. More information on these particular uses is given in Chapter Three in the "Fare Surveys" section.

Other marketing-related uses of ridership data are to determine customer perception of transit services offered and to fill requests for information from advertisers, developers, and members of the community.

Miscellaneous data uses include monitoring of system usage by wheelchair users, elderly persons, and handicapped riders for whom elevator access is important, and obtaining travel demand data of interest in modeling and other applications. WMATA has used information on Metrorail usage rates at different distances from station entrances as a promotional tool for station area joint use development. One use that the TTC makes of station activity counts is to monitor the effectiveness of staggered hours programs in smoothing out traffic peaking.

TABLE 6

REPORTED USES OF RIDERSHIP DATA IN PERFORMANCE ANALYSIS AND EXTERNAL REPORTS

Operator	Department	Data Use	Source
BART	Planning & Research - Research & Analysis Division	Monitor patronage, patron delay and capacity allocation vs. performance objectives	Entry/exit fare gate tallies (train load and performance simulation)
		Section 15 passenger miles and unlinked trips	Entry/exit fare gate tallies
CTA	Financial Reporting and Analysis, Strategic Planning	Section 15 passenger miles	Turnstile tallies, on-board checks
		Section 15 unlinked trips	Turnstile tallies, sta.-to-sta. surveys
GCRTA	Operations Division	Determine capital/operating cost per ride	Turnstile/farebox tallies
	Safety Department	Ridership data for accident rate calculation (UMTA SIRAS report)	Turnstile/farebox tallies
	Planning & Revenue Departments	Section 15 passenger miles	Turnstile/farebox tallies, on-board checks
		Section 15 unlinked trips	Turnstile/farebox tallies
MBTA	Planning Division	Monitor train/station ridership and recommend service/station changes	Passenger load counts, station boarding/alighting and transfer counts, turnstile tallies
		Summary reports of ridership, special studies	Passenger load counts, turnstile tallies, sta.-to-sta. counts/surveys, origin-destination surveys, fare surveys
		Section 15 passenger miles	Turnstile tallies, station boarding/alighting counts
		Section 15 unlinked trips	Turnstile tallies, station transfer counts
MDTA	Management Information Systems and Operations Planning	Performance analysis and external reports; state-required performance report (turnstile tallies)	Turnstile tallies, station activity counts
		Section 15 passenger miles	Turnstile tallies, on-board checks
		Section 15 unlinked trips	Turnstile tallies
MARTA	Scheduling Department	Monitor service performance	On-board checks, station boarding/alighting counts, origin-destination surveys
	Planning and Service Development	Section 15 passenger miles and unlinked trips	Turnstile tallies, sta.-to-sta. surveys
	Research and Analysis	Dertermine system ridership	Entry faregate tallies and bus transfer count data
		Special studies	Entry faregate tallies and bus transfer count data
		Analyze budget performance	Entry faregate tallies and bus transfer count data
	Safety & Training	Accident rate calculation	Entry faregate tallies and bus transfer count data
NYCTA	Transit Police	Operation enforcement study of illegal public activities	Turnstile tallies, enforcement survey (of violations)
	Operations Planning - Service & Ridership Data	Annual CBD cordon count	Passenger load counts
		Section 15 passenger miles and unlinked trips	Turnstile tallies, sta.-to-sta. surveys
SEPTA	N/I	Performance analysis and external reports	On-board checks, turnstile tallies, special surveys
		Section 15 passenger miles	Turnstile tallies (with assumptions as to average destination)
		Section 15 unlinked trips	Turnstile tallies, station transfer counts
TTC	N/I	Performance analysis and external reports; including determining trends in passenger flows at peak load point and terminal stations, usage of park-ride facilities, degree of crowding in stations	Passenger load counts, station entry and mode of access counts, origin-destination surveys, fare surveys
WMATA	N/I	Performance analysis	Passenger load counts
WMATA	N/I	Section 15 passenger miles and unlinked trips	Faregate tallies, origin-destination surveys

N/I = Not Indicated

TABLE 7

REPORTED USES OF RIDERSHIP DATA IN MARKETING AND OTHER APPLICATIONS

Operator	Department	Data Use	Source
BART	Planning & Research, Public Affairs	Measure growth by market areas, obtain rider characteristics and travel habits, evaluate Travel Demand Management	Entry/exit fare gate tallies, origin-destination/rider characteristics surveys
CTA	Strategic Planning - Market Analysis and Research Group	Identify problems with new fare media, determine characteristics and travel habits of pass users and non-users, estimate effects of fare modifications	Fare media user surveys, trip diaries, stated preference surveys
GCRTA	N/I	No use indicated	
MBTA	Marketing and Ridership	Provide requested data to community, advertisers, developers	Station boarding/alighting and transfer counts, turnstile tallies, origin-destination surveys, fare surveys
MDTA	Marketing Division	Marketing and miscellaneous	Passenger load counts, on-board checks, turnstile tallies, station activity counts, origin-destination surveys
MARTA	Marketing & Public Information	Advertising and publications	Entry faregate tallies and bus transfer count data
		Determine profile of riders to identify marketing targets	Entry faregate tallies and bus transfer count data; origin-destination surveys
NYCTA	Operations Planning - Service & Ridership Data	Monitor system usage by wheelchair, elderly and handicapped riders	Elevator count
SEPTA	N/I	Determine customer perception of services offered	Opinion survey
TTC	N/I	Marketing and miscellaneous; including monitoring staggered hours programs	Station activity counts, origin-destination surveys, fare surveys
WMATA	Planning Department	Determine usage (mode split) by building use and distance from station (used for station area development promotion)	Station activity counts
		Various planning/marketing purposes	Origin-destination surveys

N/I = Not Indicated

CHAPTER THREE

STATE OF THE PRACTICE

The description of the state of the practice of rail rapid transit ridership data collection and application which follows is based on the surveys (see Appendix B) returned by the 10 North American operators who responded. The data collection categories described are passenger load counts, on-board checks, entry-only faregate tallies, station activity counts, station-to-station surveys, origin-destination surveys, and fare surveys. For each type of data collection activity, the following areas are covered to the extent allowed by the information provided: field survey design, sample design, management and personnel requirements, training and quality control, data entry and analysis, data reliability, and data adequacy. Mention of uses to which the data are put is made where appropriate to refer back to or amplify the discussion of ridership data uses in Chapter Two.

The data collection categories used to organize the discussion have been revised from those employed in the survey to better reflect the activities reported. Terminology is necessarily a compromise among the wide variety of names given to essentially the same activity, equipment, or job by the different operators.

PASSENGER LOAD COUNTS

Counts of train car passenger loadings follow a basic approach whereby personnel are positioned on a station platform to observe and record the number of passengers in each car of each train passing through. Actual train arrival times are also recorded. Most passenger load counts are taken at the point on each rapid transit line where maximum train loading normally occurs—the maximum load point.

The count data are processed to allow use in scheduling and operations planning, as detailed in Chapter Two, most commonly to determine number of cars per train and number of trains required. A byproduct is a schedule adherence check. Table 8 lists the names given to this type of count and the departments responsible.

TABLE 8

PASSENGER LOAD COUNTS AND ASSIGNMENT OF RESPONSIBILITIES

Operator	Count Name	Department/Section
CTA	Maximum Load Point Checks	Operations Planning
GCRTA	Traffic Checker	Schedule
MBTA	Peak Load Counts	Planning
MDTA	Point Check and Train Passenger Loads	Operations Planning and Scheduling
MARTA	Rail Passenger Check	Service Monitoring
NYCTA	Rapid Stationary Load Point Check	Operations Planning: Traffic Checking and Analysis
SEPTA	Maximum Load	Planning and Development
TTC	On-Train Passenger Loads	Operational Planning
WMATA	Max Load Point Counts	Planning

All rapid transit operators covered by the survey returns conduct passenger load counts except for BART, which uses data from their entry/exit automatic fare collection system to simulate the information normally obtained from maximum load point and other passenger load counts. The BART approach is described under "Entry/Exit Faregate Tallies."

The NYCTA "Rapid Stationary Load Point Checks" are used in the following discussion to represent the prototypical all-manual passenger load count. Significant departures from the NYCTA approach that are used by other operators, including computerized processing, are highlighted.

Field Survey Design

NYCTA passenger load counts are taken, manually, as each train stops at the station. There are no interviews or questionnaires involved. Checkers are positioned on the platform to observe no more than two cars each. They record the route number, destination, arrival and departure times, car numbers, the leaving load on each car, and the lead car number.

Other operators may observe either arriving or leaving loads, and tend not to record car numbers. Some record scheduled train arrival times instead of entering that information during data processing. Operators such as the Metro-Dade Transit Agency (MDTA) in Miami, the Metropolitan Atlanta Transit Authority (MARTA), and the Greater Cleveland Regional Transit Authority (GCRTA) use procedures and forms common to both bus and rail operations. Most operators assign two cars per checker, but that ratio is not universally employed. SEPTA assigns only one car per checker, while MARTA uses a base crew size of two checkers per direction, and thus may assign as many as four cars per checker. MARTA tries to add a third checker in periods of peak loading.

The practice of having each checker record his or her own observations is almost universal. However, TTC, another operator that uses only two checkers per direction, takes an entirely different approach. TTC's procedure is to have one checker call out the train run number, and estimate and call out the passenger load on each car as it enters or leaves the station. The other checker records the time, run number, and the passenger load of each car. With six-car trains, TTC uses up to two-thirds fewer checkers than required by the procedures some other operators.

Sampling Design

Passenger load counts at NYCTA are taken wherever requested, but the predominant request is for maximum load point information. The counts may be taken at a series of stations simultaneously, providing a complete data profile similar to that produced by boarding and alighting counts. All passengers and all trains are counted during the requested time period. A 24-hour cordon count around the Manhattan CBD is taken annually in October.

At NYCTA each count covers two weekdays, not the same day of the week, but in the same month whenever possible. Care is taken to be sure that the count is not scheduled around a holiday or a "general order" in which service is diverted from its regular route because of construction.

No other operator reports taking passenger load counts for two days. All take 100 percent samples of all trains and cars at the count location for the duration of the count. Several operators schedule maximum load point counts on a recurring basis ranging in frequency from three times a year to four times a month. Some count peak periods only and others count for 12 or more hours. The timing of counts is tabulated in Table 9 for each operator.

Management and Personnel

Scheduling of NYCTA passenger load counts is done by the Traffic Checking and Analysis unit each quarter from prioritized lists submitted by the Service Planning and Rail Schedules units and from requests by other users. Blocks of assignments are given to supervisors who run the counts in the field, and deliver the results for processing. NYCTA checkers are unionized, part-time employees, and are assigned only to traffic checking and analysis duties.

SEPTA supplements its full-time checkers with a force of 120 temporary employees consisting of SEPTA retirees, policemen, firemen, and others. Both MARTA and TTC, the two operators using fewer than one checker per pair of cars, assign senior level checkers. MARTA checkers on passenger load count duty typically have more than five years of experience. Field personnel staffing requirements per count per direction were discussed above under "Field Survey Design."

TABLE 9

PASSENGER LOAD COUNT TIMING

Operator	Days	Hours
CTA	One weekday 8 times per year; annual CBD cordon count	6-9 am, 2:30-6:30 pm (1)
GCRTA	Varies	6 am - 6 pm
MBTA	One weekday 8 times per year; limited sample	6-9 am, 3-7 pm
MDTA	Quarterly; 2 days a.m. and p.m.	5:30 am -1:30 pm; 12:30 pm-8:30 pm
MARTA	Varies	6-9:30 am, 3:30-6:30 pm (2)
NYCTA	2-day counts per timing requested; annual CBD cordon count	Per timing requested
SEPTA	One weekday in each of 3 seasons	5 am - 10 pm
TTC	Varies	6 am - 1:30 am
WMATA	One weekday 4 times a month	Peak periods

(1) Annual cordon count is 16 hours.
(2) Full service check is 5 am - 1:30 am.

Training and Quality Control

NYCTA checkers are put through a three-week training program. Four to five days consist of rapid stationary load point checks (passenger load counts), queuing checks, and turnstile entry and exit checks. Quality control during the count is accomplished by the supervisor. The supervisor verifies the heading on the "Rapid Transit Traffic Check" form, and the car positions of each checker, and throughout the count skims the data recorded by the checkers looking for proper consistency and logic.

The data are reconciled against the daily incident report prepared by the supervisor indicating any irregularities that occurred during collection. This report lists the time, duration, and nature of all incidents along with route and train identification. Finally, as part of data entry and analysis, the data are run through a series of validity checks.

Reported training elsewhere ranges from on-the-job instruction and monitoring by supervisors on the CTA, to a three-day training program on the GCRTA. Quality control includes monitoring of procedures and rejection of counts showing large variations attributable to weather or service factors. MARTA monitors checker accuracy by having supervisors arrive unannounced and make comparison checks against their own on-board count of the train on which they arrived.

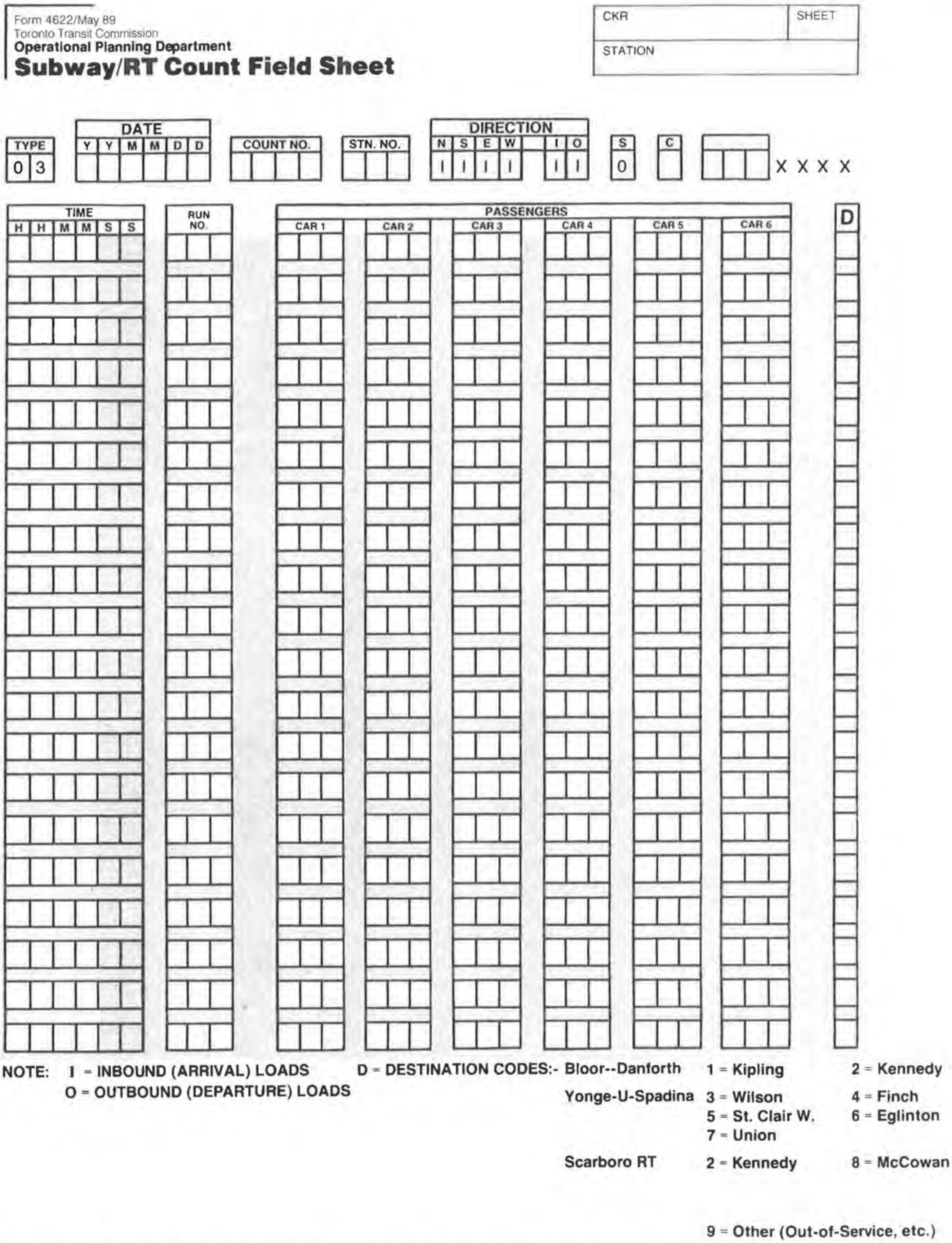
Data Entry and Analysis

At NYCTA, checkers record passenger load count data on a "Rapid Transit Traffic Check" form. From that form, data for each car are transcribed onto a "Rail Traffic Survey Tally Card." The resultant tally provides the leaving loads for each train from each station surveyed. Next the data are further summarized into 15-minute periods on a "Stationary Load Point Check Summary" for each of the two survey days. An average is then calculated to represent a "typical day." Raw data are taken directly from the "Rapid Transit Traffic Check" form to calculate running times between stations and dwell times at stations. This information is recorded on the "Running Time Summary" sheet. These four NYCTA forms are reproduced in Appendix C.

The process is entirely manual. NYCTA looks to its current "Automatic Traffic Clerking" project, described in Chapter Four, to provide for data processing automation.

Reported data entry procedures are all manual except for TTC where field sheets are fed into an optical character reader for scanning and editing. A variety of edit checks, such as validation against allowable ranges, is applied. Corrections are made manually. The data are then electronically transferred to a mainframe computer for further processing. Reports generated include a trip listing with loads by car, 15-minute summaries and averages, and summaries by peak and off-peak time periods.

Figure 1 illustrates the TTC "Subway/RT Count Field Sheet," designed for optical scanning. TTC finds optical scanning definitely quicker than manual data entry, allowing them to keep up with the workload, and is expanding the use of optical scanning to other surveys.


Form 4622/May 89
Toronto Transit Commission
Operational Planning Department
Subway/RT Count Field Sheet

CKR | SHEET
STATION

TYPE: 0 3 | DATE: Y Y M M D D | COUNT NO. | STN. NO. | DIRECTION: N S E W I O | S: 0 | C | X X X X

TIME: H H M M S S | RUN NO. | PASSENGERS: CAR 1, CAR 2, CAR 3, CAR 4, CAR 5, CAR 6 | D

NOTE: I = INBOUND (ARRIVAL) LOADS
O = OUTBOUND (DEPARTURE) LOADS

D = DESTINATION CODES:-
Bloor--Danforth: 1 = Kipling, 2 = Kennedy
Yonge-U-Spadina: 3 = Wilson, 4 = Finch, 5 = St. Clair W., 6 = Eglinton, 7 = Union
Scarboro RT: 2 = Kennedy, 8 = McCowan
9 = Other (Out-of-Service, etc.)

FIGURE 1. Toronto Transit Commission Passenger Load Count Field Sheet, Designed for Optical Scanning.

Several properties report considering use of hand-held data entry devices, but none reports implementation of their use for rail rapid transit passenger load counts. CTA has actual experience with the use of hand-held data entry devices for on-board checks, described in connection with that type of count. A full accounting of the status of hand-held data entry device applications in rail rapid transit passenger data collection is given in Chapter Four.

In addition to TTC's automated data entry and mainframe computer analysis, several operators report using personal computers (PCs) to process passenger load counts once data are entered. MARTA, for example, produces a computer printout of loads and load factors by car and by train. Standard PC spreadsheet and data base programs are commonly employed. SEPTA also currently is testing commercial transit ridership data analysis software, as described further in Chapter Four.

Data Reliability

With respect to possible sampling error, NYCTA feels that passenger load count data constructed from two days within the same month provides a sufficient basis for meeting their needs. They advise that data must be applied in the context of the season in which they were obtained and the type of schedule in effect. MBTA reports concern that their sampling of twice per quarter is adversely affected by variations in weather, train service, etc. No operator reported doing statistically based sampling or analysis of variability by season, time, or day of week, or any evaluation to determine their effect on count reliability.

NYCTA and MBTA both report problems in estimating passengers when cars are packed with standees. NYCTA now has checkers enter "crush load" instead of an estimate, and the capacity for the car series involved is substituted during data processing. Preparation for this survey modification required determining crush load capacity for the different equipment types, involving calculation of square footage and conduct of car loading trials. When mixed fleets are operated this solution does require entry of car numbers on the field sheet.

TTC has validated their two-person team technique of having one checker observe and the other record by conducting blind tests. Two-person teams replicated counts made by unannounced checkers on board within 5 percent. MARTA, the other operator assigning more than two cars per checker, also expects 5 percent accuracy. TTC reports that use of an optical character reader for data entry does not necessarily provide more accuracy than keying in the data; the improvement offered is in time savings.

Data Adequacy and Cost

In general, the responding rapid transit operators report that for the purpose of planning schedules and service, their passenger load counts are adequate. Manual data processing retards data availability. One data user reports a consistency problem resulting from having different peak period time definitions for manual passenger load count collection as compared to ridership accumulation from automatic faregates.

With the exception of BART, which simulates passenger load counts from faregate data, only TTC is satisfied that their passenger load count process is "state of the art." That does not mean that other operators are dissatisfied with the adequacy of their end product, aside from desire by some for more survey coverage and quicker response to information needs. Almost all of the available assessments of data adequacy and data collection efficiency are essentially anecdotal. Rail rapid transit passenger data collection activities that have been practiced for many years, like passenger load counting, have been subject to almost no statistical evaluation.

The reported annual expense of passenger load counts is $25,000 for GCRTA; $37,500 for MBTA; $20,000 for SEPTA; and $100,000 for WMATA. These costs should be considered in context with both system size and frequency of counting. Refer to Table 9 for information on count frequency.

ON-BOARD CHECKS

On-board checks, or on-board boarding and alighting counts, use a survey design that is fairly uniform among operators and similar to procedures employed on buses. Checkers ride cars of the trains being surveyed and record the number of passengers boarding and alighting at each stop, and also keep a record of the passenger load on the train. Train arrival and/or departure times are also recorded.

The processed count data are put to the same scheduling and operations planning uses as passenger load count data, and also facilitate studies requiring a profile of passenger activity for the length of a route. MDTA, GCRTA, and CTA use on-board checks to obtain the passenger trip length data mandated by UMTA Section 15 requirements. SEPTA in Philadelphia and NYCTA use on-board checks in situations where a low number of trains makes them economical, as in the case of certain shuttles or nighttime "owl" services, and to meet special needs.

On-board checks are less common on rail rapid transit than on surface transit. Several rail rapid transit operators made no specific mention of using on-board checks. Rail rapid transit's use of stations spaced apart, with recording fare collection equipment, offers data collection alternatives with economies of scale that are not available to local bus passenger data collection.

Field Survey Design

On-board checks, as contrasted to on-board surveys, involve no interviews or questionnaires. Checkers are positioned, generally on each car of a train, to record passenger activity and time information. In a New York "Rapid Ridecheck," NYCTA checkers record actual arrival time, passenger alightings, boardings, the passenger load leaving, and the leaving time as the train serves each station. Scheduled train times are added during data processing.

In Miami, MDTA on-board checks include the passenger load leaving each station, and scheduled arrival and departure times are recorded along with the actual times. The MDTA field sheet is reproduced in Appendix C.

One form is filled out per trip. Station names are generally printed on the form or filled out in advance. Each form requires checker entry of identification data such as date, start and finish time, train number, run number, car location within the train (1, 2, 3, 4, etc.), and other information of interest to the operator.

CTA is now using hand-held data collection devices for its rail rapid transit Section 15 on-board surveys. The devices have an alphanumeric keyboard, a bar code reader, and four function keys. A list of station stops is downloaded into a hand-held data collection device in preparation for each count sequence. The checker calls up the appropriate station name at each stop, either by keying in the appropriate serial number, or by moving forward or backward in the list of station stops. The time is recorded, and the count is then entered using the four function keys. One keystroke is made per passenger, like a mechanical counter. One function key is for boarding passengers, one is for alighting passengers, and the other two are for subtractions to correct errors. Passenger loads are calculated and displayed, along with the station name, on a two-line screen. CTA deliberately has had the hand-held data collection devices programmed to allow the checker to review the data already collected and enter adjustments deemed appropriate.

Required ancillary information, such as the train conductor's badge number, is keyed in after entry of the applicable instruction code. Each checker carries a three-by-five-inch card containing bar codes that can be used to make the instruction entries. CTA implemented use of hand-held data collection devices on the rail rapid transit system first, because station stop listings and distances between stations were readily available.

Sampling Design

Except in the case of collecting UMTA Section 15 trip length data, on-board checks generally cover all cars from all trains within the span of the study design. Route and time-span coverage vary according to the objective of the survey. NYCTA follows the same practice of gathering data on two different weekdays that they follow for passenger load counts.

Section 15 rail rapid transit data sampling plans vary from operator to operator, even among those who use on-board checks as the data source. UMTA does not provide a suggested Section 15 data gathering approach for rail rapid transit. A performance standard is specified instead, requiring that a 10 percent precision be obtained at the 95 percent confidence level. CTA procedures for Section 15 on-board sampling have been published in detail, and serve as an example (*1*).

CTA uses a stratified sample of terminus to terminus train trips, stratifying by time of day and day of week into a.m. peak, midday, p.m. peak, other weekday, Saturday, and Sunday intervals. Samples, a total of 300 train trips in all, are selected from each stratum based on the proportion of unlinked rail trips occurring in each time period. A random sample of train trips within each stratum is selected on a monthly basis. One car is surveyed within each train selected. Selection of the car within the train is also random. CTA adopted stratified sampling out of concern that the unique trip length characteristics of peak hour travel, which is characterized by higher car loadings, would otherwise be underrepresented.

Management and Personnel

Most on-board checks are accomplished under the same management controls and staffing arrangements as the individual operator uses for passenger load counts. Count crews generally consist of one checker for each car under observation, plus supervisory personnel, although the MDTA reports having one checker cover two cars on early morning and late evening runs, and on weekends. Personnel assigned to CTA's on-board Section 15 data collection effort are drawn from a staff of field data collectors who are hired at up to $25,000/year and are not limited by standard traffic checking work rules. Since they survey individual cars on individual runs, they must work without close supervision.

Training and Quality Control

Training and quality control are essentially the same as for passenger load counts, modified as appropriate for the different requirements of on-board checks. For example, NYCTA supervisors go through each train to review the work of the checkers, instead of from station to station. CTA reports that it is fairly easy to train checkers in the use of hand-held data entry devices.

Data Entry and Analysis

The field sheet used by NYCTA is called a "Rapid Ride Check" form. From that form, data for each car are transcribed onto the same "Rail Traffic Survey Tally Card" used for passenger load counts. All of the remaining steps in the process are identical to processing passenger load counts, and use the same forms. The "Running Time Summary" sheet is filled out directly from the "Rapid Ride Check" form. As with passenger load counts, the NYCTA process is entirely manual.

MDTA in Miami and SEPTA in Philadelphia also enter their on-board check data manually, but MDTA has purchased and is currently programming hand-held data entry devices for both bus and rail on-board checks. No specific mention was made by responding operators about use of automatic data processing, except for CTA. When an on-board check is done for special purposes, the study design and analysis are specially tailored to the end user's needs.

CTA transfers data from their hand-held data entry devices directly into a PC via cable connection. Analysis programs in the PC pull in the data and apply distances between stations to compute the passenger trip lengths required for Section 15 reporting. Further information on the CTA hand-held data entry devices and software is provided in Chapter Four.

Data Reliability and Adequacy

Data reliability concerns and quality control procedures for on-board checks generally parallel the concerns and procedures that apply to passenger load counts. Those on-board checks conducted as the basis for fulfilling Section 15 data requirements must meet the statistical tests specified by UMTA.

CTA staff feel that use of hand-held data entry devices is meeting the objectives for improved accuracy and reduced cost. The objectives included freeing the checker in the field from paper and pencils, providing improved capability to keep up with the pace of passenger movement, allowing results to be viewed while the check is in progress, and eliminating the manual data entry step following field data collection, providing quicker data collection/analysis turnaround time.

ENTRY/EXIT FAREGATE TALLIES

There are two basic types of rail rapid transit fare collection in North America: flat fare collection on entry, and distance-based fare collection keyed to the combination of entry and exit stations used by the passenger. Collection on entry does not require faregates at station exits, whereas fare collection keyed to both entry and exit stations does.

Fare control at both entry and exit tends to provide substantially more passenger data than entry-only fare collection for two reasons, only the first of which is inherent:

1. Fares that require control at both entry and exit inherently hold the potential of providing station-level origin-destination data. Entry-only fare collection tells nothing about the passenger's destination.
2. The entry/exit fare collection systems are among the newest and most highly automated. Much of the entry-only fare collection equipment ranges from less than state-of-the-art to antique.

The level of information available from entry-only fare collection should improve as older fare collection equipment is replaced.

In recognition of the major differences between entry-only and entry/exit fare control systems, entry/exit faregate tallies are discussed here first, separate from entry-only faregate tallies. BART is the pioneer in fully automated passenger data collection in connection with entry/exit fare collection. The BART system is used in the following discussion to portray entry/exit faregate passenger data collection. The WMATA system has equivalent data collection potential, not yet fully implemented. The WMATA system is referenced as appropriate to add perspective.

All rail rapid transit faregate and turnstile tallies provide data for financial control and analysis, and for operational and design studies that make use of station entry counts, as covered in Chapter Two. Additional uses of entry/exit faregate tallies are expanded upon in the "Data Entry and Analysis" discussion below.

Data Collection Design

Tallying of BART faregate data involves no field survey design or sampling design in the traditional sense. Patronage data are collected for all revenue trips by computers linked directly to the faregates. A 100 percent sample is thus collected without direct human intervention. BART calls this their "Data Acquisition System." WMATA faregates are also directly linked to an on-line computer.

BART and WMATA use magnetically encoded stored-fare cards. The exit faregate must read the entry station code that was entered on the fare card by the entry faregate, compute the correct fare, and deduct it from the value stored on the card. BART's Data Acquisition System operates by capturing the trip information from this transaction and reporting station-to-station passenger flows at two-minute intervals.

This trip information is necessarily organized from the point-of-exit perspective; the times associated with the trip data are point-of-exit times, not point-of-entry. The trip data are station-level origin-destination data. The station of origin and station of destination are identified, comparable to a "station-to-station survey," but the primary origin or ultimate destination of the passenger's door-to-door trip are not.

BART obtains train movement data from its central computer train control system for combination with the passenger data in train loading and performance measure calculation. A complete record of each time a train opens or closes its doors is accumulated by the train control system. Performance measure calculations are accomplished within BART's "Performance Monitoring System." Data flows into and out of the Performance Monitoring System are illustrated in Figure 2 (*2*).

Management and Personnel

BART's Planning and Research department is responsible for operation of their Data Acquisition System and Performance Monitoring System. One analyst and two to three technicians constitute the staff requirement. At WMATA responsibility lies with the Planning and the Management Information System departments, along with the Rail Division.

Training and Quality Control

Since BART's Data Acquisition System is an automated process, there is no field crew training involved. Checking for errors is done manually, however. The primary indicator used in this check is the ratio of entries to exits at each station, a statistic included in each day's report. A daily comparison is made to historical patterns for this ratio. Deviations from expected patterns usually indicate problems, and are investigated carefully.

WMATA reports that biases occur when gate registers fail or there is a communications drop between a station mezzanine and the mainframe computer.

Data Entry and Analysis

The data from BART's Data Acquisition System are output each day in a series of reports. These reports, in machine readable format, are input to the Performance Monitoring System. The Performance Monitoring System also reads the computer generated train history tapes from the train control system, and, by matching train and patron data by time of day, simulates the loading of each train. These simulated patron count data by train are used to monitor train loadings at maximum load points, and also to estimate the proportion of riders whose trip is on-time in terms of the published schedule.

Figure 3 (*3*) illustrates the computer programs used within the BART Performance Monitoring System, and also the data flows involved. Program 1, Automated Edit of Train Actions, assembles door opening and closure times from the train control system into train runs. Program 2, Compare Trains with Timetable, identifies each of these actual train runs with corresponding train runs in the timetable. Along with standard on-time performance measures, a train delay event list is generated, identi-

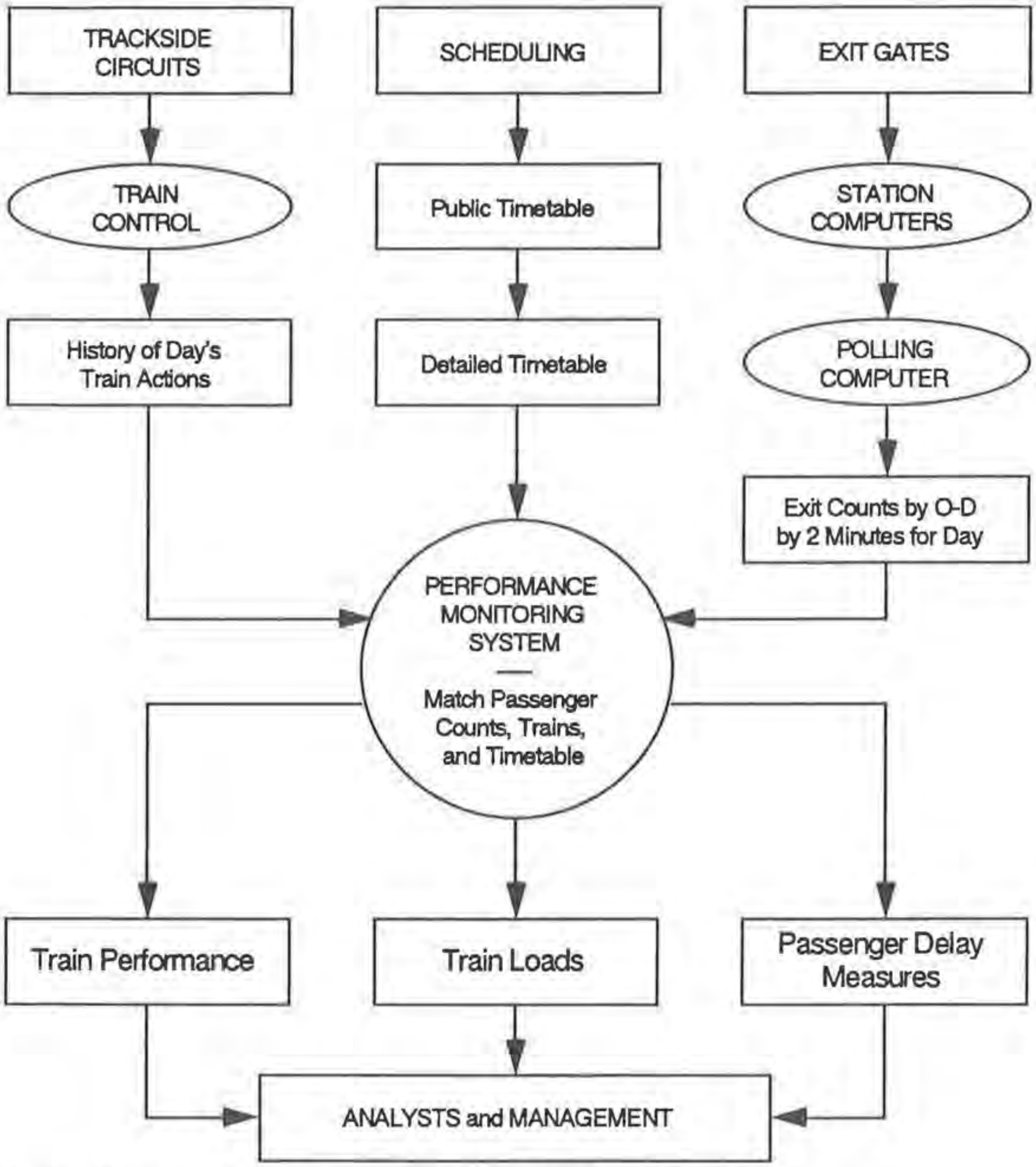


FIGURE 2. Data Flows into and out of the BART Performance Monitoring System (*2*).

fying each delay by location. This list is used in next-day analysis of train delays. It helps distinguish between delays directly caused by a failure and secondary delays caused by the resultant train congestion, and allows accurate analysis of delays.

Program 3, Match Passengers with Trains, is a deterministic program for assigning the passenger trips from the Data Acquisition System reports to the trains identified in Program 2, Compare Trains with Timetable. Since the passenger trips are identified by their exit times, the program must work backwards from the exit stations. After allowing for processing time in the exit station, the passenger trips are loaded onto the most recent train from the passenger's origin station, or from the appropriate transfer point if applicable. Transfer passengers are in turn loaded onto the most recent connecting train from the passenger origin to the transfer point.

The assignment of passengers to individual trains within this program produces train loadings. After averaging over 10 weeks, with separate moving averages for each day of the week, the train loadings at five critical locations are used in optimizing allocation of train cars. Passenger loads are also reported quarterly and used in long range planning. Analysis of peaking is used in support of Travel Demand Management actions such as flextime.

In Program 4, Compare Patron Trips with Timetable, actual and expected travel times for each entire day of patron trips are calculated and compared. To do so, the program must estimate

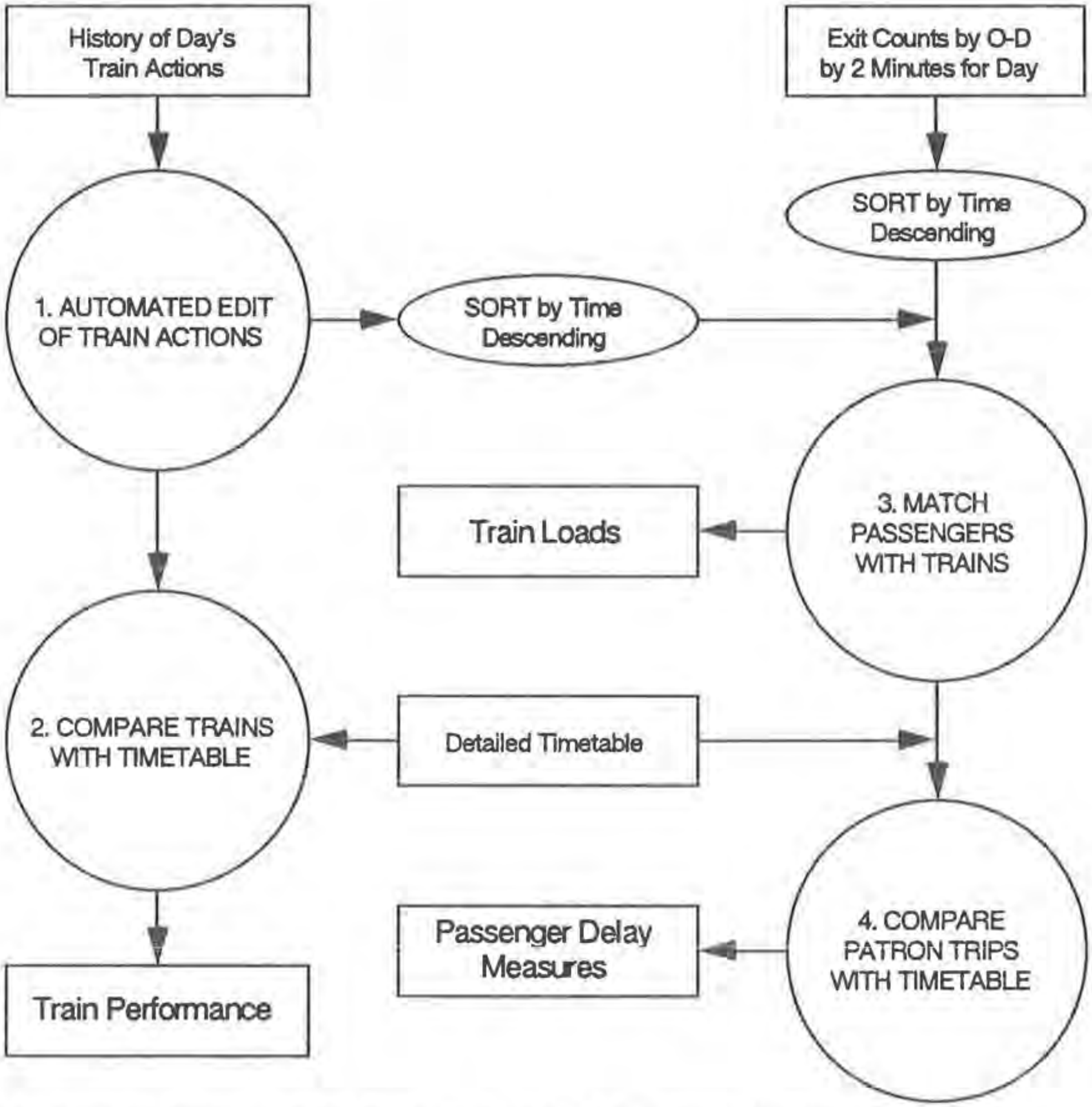


FIGURE 3. Computer Programs and Data Flows within the BART Performance Monitoring System (*3*).

the arrival times of passengers at their origin station. It makes this estimate by working backward from the origin station train departure times assigned in Program 3, Match Passengers with Trains. Arrival time in advance of train departure is estimated on the basis of passenger arrival distributions developed for a mix of randomly arriving passengers and passengers assumed to use a public timetable. Program 4 identifies both the waiting-time and enroute-time components of delay in the performance measure data it produces.

At present WMATA uses its data retrieval system to take mezzanine counts at 15-minute intervals for both entering and exiting passengers, along with information on the fare extracted. Summaries are produced by peak period, midday, evening, and all day; and average fares are computed. WMATA raw data contains the time of station entry as well as the time of station exit.

Data Reliability

BART estimates that the unreported passenger count typically does not exceed the reported count by more than 2 percent on a monthly basis. There are times when the Data Acquisition System fails systemwide or at individual gates or an array of faregates, requiring data estimation. The accuracy of the train loadings estimated by the Performance Monitoring System has been checked by walking through trains and counting passengers, and is reported to be very high.

In the course of using their faregate tallies for estimating future faregate requirements, WMATA found that the time faregate transactions took place could not always be read. The transactions with times that could not be decoded were on the order of 2–3 percent.

Adequacy and Cost

BART is very satisfied with their Data Acquisition System and Performance Monitoring System on most counts. They produce passenger loading data on a daily basis that would otherwise have to be obtained with less frequent passenger load counts and passenger surveys, and offer performance measures that would not be produced at all without some sort of comparable data management system. The WMATA system is not as fully developed yet, but is felt to perform its current functions well.

The BART system does not provide separate time of day or origin-destination information for holders of special tickets, such as handicapped, youth and seniors, or other discount fare categories. Neither does it currently provide linked-trip data for bus-to-rail transfer trips. The BART Universal Ticket Project, which would provide linked-trip data, is discussed in Chapter Four.

The annual operating cost of the BART system is estimated to be $200,000. This cost assumes three technicians to maintain the electronic data collection system and one analyst to oversee data processing, analysis, and reporting. The original development and acquisition cost of the system was substantial. WMATA reports an annual faregate count collection cost of $100,000 under the present operating mode, which does not provide origin-destination data.

ENTRY-ONLY FAREGATE TALLIES

Rail rapid transit fare collection that does not require exit station fare control is accomplished with faregates, turnstiles, agents, and sometimes train conductors; even with motormen and women in "one-person" operations. Some systems have intermodal stations where passenger transfers from buses or streetcars take place within the station's "fare paid" area, allowing barrier-free entry for riders who paid their fare on connecting services. The passenger data collection opportunities and constraints of the different entry-only fare control systems thus vary considerably, as do the data collection techniques. Between the synthesis survey and preparation of this synthesis report, both GCRTA and SEPTA installed new fare collection equipment and revised their data collection accordingly.

CTA's procedures are used here as an example of comprehensive collection and analysis of passenger data obtained in connection with multiple entry-only fare collection configurations. Noteworthy variations from the CTA approach are identified, but without dwelling on procedures or problems uniquely associated with equipment in disrepair and/or scheduled for replacement. Table 10 lists each type of rail rapid transit fare collected by CTA and indicates the fare collection equipment or personnel used.

Passenger data collection in connection with entry/exit fare collection was covered in the preceding section. Faregate tallies are used for financial control and analysis, to estimate total ridership, and for operational and design studies, as described previously.

Field Survey Design

Passenger data collection in connection with entry-only fare collection operates in two different modes, which might be called a "standard mode" and a "special mode." In the standard mode, data are accumulated on a daily basis, or less frequently in some instances. In the special mode, data are recorded at more frequent intervals and/or in greater detail, for some special purpose. SEPTA's new automatic fare collection equipment provides an exception; when passenger data transmission is fully up and running the standard mode for data reporting will be at least hourly. The capabilities of SEPTA's automatic fare collection equipment are described in Chapter Four.

At CTA, one or more agents working in an enclosed booth is the most common method of fare collection. For standard-mode passenger data collection and revenue control, fare collection agents prepare an "Agent's Report" covering their shift. Included in the report are the start and finish readings of registers that are contained in the agent console, essentially a specialized cash register. There are separate readings for each class of fare and a reading for total entering traffic, which at almost all locations is produced by a turnstile. The forms are put in the booth's drop safe, and are collected along with the fares. This form is reproduced in Appendix C. Conductors, who collect fares where and when station use is at low levels, fill out a similar form from readings on their portable mechanical register, and from transfer pad serial numbers.

Readings for CTA coin-operated turnstiles, those not under direct control of an agent, are obtained by the "foot collectors" who go from station to station to collect the cashboxes on a regular schedule that is closely adhered to. Collection frequency varies from daily at busy stations to three times a week at other stations. Each reading is allocated to individual days as part of data analysis.

NYCTA station agents take turnstile readings each shift, or more often if tokens are retrieved for resale. GCRTA station attendants telephone the readings on their turnstile registers to the rail dispatcher at 6:00 a.m. each weekday. This procedure was terminated upon recent installation of registering fareboxes at all Cleveland rail rapid transit station booths, but has been reinstituted, at least temporarily, as a cross check on both station booth and on-train farebox readings. The cross check against on-train fareboxes, which are used in off-peak hours, is necessarily made in the aggregate, whereas station fareboxes can be checked individually.

GCRTA supplements its farebox/turnstile readings with periodic systemwide passenger boarding counts made by the train operators, designed to obtain factors for segregating out weekend ridership. These are necessary because the registering fareboxes are not dumped over the weekend, and no tallies are made.

Beginning and closing readings by fare category are obtained daily from MDTA turnstiles by inserting a series of "register cards" which cause selected readings to be displayed. This data collection is performed by the station guards. The readings must be supplemented by a cash count of paper and other money deposited in "user friendly" drop boxes, under guard supervision, by passengers who lack the coins accepted by the turnstiles. This cash is collected daily at midnight by finance department personnel, and is equated to passengers on the basis of the adult fare.

MBTA and TTC faregate tallies must be accompanied by tallies of passengers entering through gates manned by a collector without a booth or turnstile. Fares at these gates, open only during periods of peak passenger flow, are deposited in a drop box. The passenger count at such gates must be derived based on

TABLE 10

PROCEDURES AND SYSTEMS FOR FARE CONTROL AND COLLECTION - CHICAGO TRANSIT AUTHORITY

Control	Fare Category	Fare Media	Equipment/Personnel
Entry-only	Standard flat fare	Cash	Turnstiles, agents, on-train fare collection
	10-ride discount	Tokens	Turnstiles, agents, on-train fare collection
	Reduced fares	Cash, tokens	Agents, on-train fare collection
	Monthly passes	Flash pass	Agents, on-train fare collection
		Electronic card	Turnstiles with pass readers, agents, on-train fare collection
	Transfers sold	Paper transfers	Turnstiles with transfer dispensers, agents, on-train fare collection
	Transfers received	Paper transfers	Agents, on-train fare collection
	Express surcharge	Cash	Agents, on-train fare collection

fare mix surveys. On the TTC system, which also has intermodal stations allowing barrier-free entry for riders transferring from connecting services, turnstile readings are no longer used for daily patronage estimation. Patronage is estimated based entirely on the rail rapid transit revenue count, average fare data, and a transfer rate factor. The transfer rate factor is based on both station entry counts, described below under "station activity counts," and bus/streetcar on-board checks, using a 3-year average.

MARTA, which also has intermodal stations with barrier-free transfer passenger entry, relies on monthly faregate tallies. Count data for 12 fare categories are gathered between 1 a.m. and 5 a.m. on the day of the tally. Counts of transfer passengers at intermodal stations are also made monthly, covering one full service weekday, one Saturday, and one Sunday. The evening, Saturday, and Sunday count is sometimes estimated. Transfer passengers at other stations are included in the faregate tallies as they enter using paper transfers with a magnetic strip, which are recorded as one of the 12 fare categories.

In a typical special-mode "Turnstile Entry and Exit Count," NYCTA checkers record a station's turnstile register readings at 15 to 60 minute intervals, and also obtain counts of "fare beaters" who slip past the turnstiles without paying, along with a breakdown of persons using gates intended primarily for passholders. The latter breakdown distinguishes among uniformed personnel, fare beaters, school pass holders, and all others. Concurrently, exit counts are taken with hand-held mechanical counters. NYCTA conducted a Turnstile Entry and Exit Count of the system, with 24-hour coverage, in 1988.

CTA takes half-hourly entry readings on a six-year cycle, one line per year. This count covers Thursday, Friday, Saturday, and Sunday for two weeks. MDTA takes hourly readings once each quarter.

Sampling Design

Standard-mode passenger data collection regarding fare collection inherently covers a 100 percent sample, either seven days a week, 52 weeks a year, or monthly. In special-mode and other supplemental counts, all passengers are counted during the specified time period. No statistical analyses related to sample selection for turnstile tallies or associated counts were reported in the synthesis survey.

Prior to installation of automatic fare collection equipment, SEPTA conducted a periodic 24-hour count of off-peak senior citizen riders as the basis for state reimbursement of the senior citizen fare subsidy. The count was taken every 26 days beginning in October of the fiscal year, thereby covering each day of the week twice a year.

Management and Personnel

CTA's standard-mode passenger data collection and revenue control involves all station agents and foot collectors, and all conductors who handle fares as part of their regularly assigned duties. Auditors and key-punch operators are involved during processing. At the other extreme, MARTA's monthly tally and associated count programs are conducted independent of revenue collection. CTA's effort encompasses revenue control, whereas the MARTA approach does not.

Special-mode counts typically involve the same types of staffing and responsibility assignments as were described earlier for passenger load counts.

Training and Quality Control

At CTA, being tied in with revenue control, the individual agent or conductor reports must match exactly the fares collected. Performance control specialists monitor fare collection activities incognito.

The MBTA reports that their quality control measures consist of making comparisons with previous counts. NYCTA devotes between 10 and 12 hours of their three-week checker training program to special turnstile entry and exit counts.

Data Entry and Analysis

Manual entry is the only means of data entry reported, excepting SEPTA's new automated fare collection system, which is being set up for automatic data transmission. CTA, after keying in the passenger data from the agent's reports and the other reporting forms employed, manipulates the rail revenue data base using a mainframe computer program. The required computations include allocation of turnstile tallies to calendar days, distribution of cash fares recorded by conductors among stations without agents on duty, and estimation of pass and transfer riders monitored by conductors. These calculations are based on CTA's Traffic Monitoring Project and special counts. Totals by time period, fare class, and station are produced. Among the reports prepared are monthly rail system traffic reports that include average weekday, Saturday, and Sunday volumes by station and traffic trends by fare category.

MDTA and NYCTA report using computer-based spreadsheets for standard-mode and special-mode data analysis. MDTA reports adjusting their count of ridership to match revenues, and other operators undoubtedly make similar adjustments.

Data Reliability

The structure of individual fare collection systems may require some patronage components to be estimated, as described above for CTA passenger data analysis. Systems with barrier-free entry for bus or streetcar transfer passengers must use manual counts or count based factors in order to include these passengers, bringing the reliability of the resulting patronage estimate down to the level of reliability of the manual counts involved. Data reliability is adversely affected by malfunctioning equipment, a particular problem with older, mechanical registers. If turnstile register readings are taken only when vaults are changed, and if scheduling problems cause this to occur at variable times during the operating day, then the count may include variable portions of two or more days. Lack of data consistency from day to day is a potential problem with this procedure.

The MBTA forthrightly lists factors detracting from reliability in publishing their ridership statistics. The list includes frequently malfunctioning mechanical turnstile counters and pass reader counters, irregularities in timing of turnstile readings, deposition of adult cash fares in cash boxes intended for reduced fare passengers, and lack of a count at entries manned by gatepersons during peak periods and special events, requiring estimation. These factors may result in problems with the total count, misallocation among days of the week, or misallocation among fare categories. For example, if the counter on a pass reader fails, too few passengers are subtracted from the turnstile count, and pass entries are counted as cash fare entries.

NYCTA's analysis of their 1988 Systemwide Entry and Exit Count revealed an exit undercount of approximately 600,000 riders—roughly a 15 percent undercount. Whereas the entry counts were turnstile register based, the exit counts rely on use of hand-held counters, and the exit count apparently is understated where volumes are high.

Data Adequacy and Cost

Some of the rail rapid transit operators with entry-only fare collection systems appear able to make extensive and satisfactory use of the ridership data they obtain in conjunction with fare collection. Others of the responding operators clearly doubt that this type of passenger data is consistently reliable under their own particular circumstances.

The reported annual expense of daily turnstile data collection is $25,000 for GCRTA. No other cost breakouts for entry-only systems were reported, but WMATA's faregate count cost of $100,000, which does not presently include entry/exit origin-destination data collection, may be indicative of entry-only automated data collection costs for similarly sized systems. SEPTA's special off-peak senior citizen count used to cost $10,000 annually.

STATION ACTIVITY COUNTS

Counts and surveys of a broad variety are taken for the purpose of quantifying and better understanding traffic volumes and ridership characteristics in and around rail rapid transit stations. These passenger data gathering activities range from boarding and alighting counts made from station platforms, to counts of passenger flows and activity within stations and approaching stations, to ridership generation by land uses surrounding stations.

Station activity counts are too diverse to allow a comparative discussion following the outline used in most other sections of this chapter. Instead, they are covered here one type at a time.

Boarding and Alighting Counts

Passenger boarding and alighting counts, already covered to the extent that they are made with on-board checks, are sometimes taken from station platforms. Taken at a series of stations along a line, boarding and alighting counts at stations can provide almost all of the same information as is collected in on-board checks. This type of station activity count can distinguish between riders using different trains and lines, but at a transfer station, cannot separate riders entering or exiting the system from riders changing trains. However, boarding and alighting counts can be combined with counts of transfer volumes to gain a complete picture of on, off, and transfer volumes by direction.

MBTA arranges such counts to supplement their standard data collection. These are among the counts taken and analyzed on behalf of MBTA by the Central Transportation Planning Staff (CTPS), an interagency staff created and directed by the Metropolitan Planning Organization (MPO). CTPS performs most MBTA ridership data collection and analysis except passenger load counts and turnstile tallies.

MBTA/CTPS count boardings and alightings on a train-by-train basis. Normally the count covers 100 percent of all trains serving the station platforms of interest. Such counts are scheduled between 7 a.m. and 9 p.m. or to cover the full service day, using a one-weekday sample. The data are collected and entered manually. A typical report tabulates line ridership by station by hour. MBTA/CTPS do not record train arrival times as part of their boarding and alighting counts.

In 1989 MBTA/CTPS took comprehensive boarding, alighting, and interline transfer counts covering the entire high platform rail rapid transit system. These counts dovetailed with counts taken in 1985 on the low platform subway-surface Green Line. The complete on, off, and transfer volumes by direction provided by the combined surveys are used to compute link volumes. One of the uses of these link volumes is in computation of MBTA's trip length data for UMTA Section 15 reporting. The 1989 counts were timed specifically to prepare for planning of future improvements to the MBTA rapid transit system.

Certain consistency problems have been encountered in the MBTA/CTPS counts. Difficulties in integrating station-based boarding and alighting count results with observed maximum load point counts are reported. The infrequent timing of the counts, 1978 being the date of the systemwide survey previous to the 1985/1989 efforts, makes trend analysis and related evaluations difficult on a system that has undergone significant rapid transit route extensions and relocations.

Station Transfer Counts

As described above, station transfer counts may be included in the design of station-based boarding and alighting counts. They are also taken as independent surveys focusing entirely on counting the number of passengers transferring from one transit line to another, particularly rail transit lines using the same station fare-paid area. The deployment of count personnel and even the feasibility of station transfer counts depends on station design and the ability to see and identify who is and who is not a transfer passenger. Isolating transfer passengers by direction of the trains they transfer from and to, as is desirable, may be even more difficult than simple transfer passenger identification.

One use that MBTA makes of its transfer counts taken in conjunction with boarding and alighting counts is estimation of unlinked rail rapid transit trips as required by UMTA Section 15 reporting. SEPTA uses independently scheduled transfer counts to do the same. This particular use does not require separation of passengers by direction of flow.

Enforcement Survey

NYCTA's Traffic Checking and Analysis Section conducts several surveys relating to train scheduling and passenger environment which are not reported here because they pertain to operator and equipment monitoring rather than ridership data. They also conduct a related survey called "Operation Enforcement," that counts people, passengers or otherwise, who are violating NYCTA rules of conduct. The Operation Enforcement task force is the primary consumer of the data, along with the Stations Department, transit police, and a committee to help with the homeless problem.

The NYCTA Operation Enforcement survey is a station area survey. Checkers record the weather in detail (hot, warm, cold, below freezing, rain, snow), presence of police, and turnstile readings. They record and describe fare violations, obstructions, solicitation/begging, unlawful commercial activity, non-transit uses, disorderly conduct, trespassing in restricted areas, and other problems.

The surveys are made monthly at stations with a history of extensive problems as identified by transit police. All stations are surveyed every quarter. The surveys are taken from 7-9 a.m., 11 a.m.-1 p.m., 4-6 p.m., and midnight-2 a.m. The original training program was designed with transit police input. The checkers involved now receive special training for one or two days from a supervisor. A supervisor monitors once per shift. Data are entered into a computer database file, validated and error checked manually, and summarized by the System Analysis unit. The survey necessarily requires subjective judgements on the part of the checker as to what constitutes an infraction, but meets basic needs for monitoring of enforcement effectiveness and impartial identification of problem areas.

Elevator Counts

Elevator counts have been instituted by NYCTA, primarily for the purpose of monitoring system usage by wheelchair, elderly, and handicapped riders. This is a new process, so there is no information on potential biases, such as possible effects of weather on elderly, and handicapped travel patterns. The current approach is to take 24-hour manual counts covering three weekdays and average them to produce a composite weekday. Senior citizens, wheelchair users, disabled persons, and all other persons using the elevator are tallied separately each 15 minutes.

Queuing Counts

NYCTA takes token booth queuing counts to monitor transaction times and the time that passengers wait in line. Stations and time spans for the count are selected by the Stations Department based on knowledge of previous queuing problems. Each observation consists of a patron arriving in line. The number of people in line, start time, leave time, and checker comments are recorded. Difficulties encountered include determining where the queue ends, and producing accurate measurements from one-person queues.

Training consists of one five-hour session, which is also the minimum time span over which such surveys are conducted. The count data are entered into a computer-based spreadsheet, and then rules-of-thumb are applied for quality control; for example, the known average time of 15 seconds per transaction. Mean transaction time and mean, minimum, and maximum time of waiting in line are computed for each hour of the count.

A queuing count would obviously be applicable to fare dispensing machines as well as manned booths. The NYCTA queuing counts, which were initiated when the $1.15 fare was introduced, cost $5,000 per limited application.

Station Entry Counts

TTC prepares an annual "Subway Station Usage Count" that is used to research the growth of development at individual subway stations and of the system as a whole. The information is also of use in monitoring staggered hours programs, degrees of crowding in stations, and determining the rental for concession areas. CTA takes similar station entering/leaving counts to monitor station use and review station agent assignments.

TTC positions field staff strategically within the station to record all passenger movements on stairs and escalators during the hours of station operation. The focus of the counts is on patrons moving to and from the subway platform; other users of the station are not included. TTC's total field crew for this project is one supervisor, two senior traffic checkers, and 45 traffic checkers. The counts are of 100 percent of weekday passenger traffic, are normally made in the first quarter of each calendar year, and are entered manually for analysis. The results are published in a report that provides passenger usage totals for each station on a normal weekday, historical summaries dating back to station opening, and systemwide summaries by time period throughout the day.

CTA assigns schedule checkers to count each station entrance and exit between 5:30 a.m. and 10 p.m. Counts are scheduled as needed, and the count crew size depends on station configuration. Data are entered manually, and entering and exiting passenger traffic is summarized by half hour.

Mode of Access Counts

TTC also undertakes an annual "Modal Split Count Program" to determine passenger mode of access and park-and-ride lot usage characteristics. The modes of access are bus, park-and-ride, kiss-and-ride, and walk-ins. The count program covers four terminal stations and two other major multimodal stations. Information gathered is used in planning access system improvements and in developing design criteria for future operations.

The count program actually consists of six different types of counts conducted simultaneously from 6:30 a.m. to 12 midnight, conducted in November and December of each year. The information recorded by each of the six counts, at 15- and 30-minute intervals, covers:

- Vehicles and passengers entering and exiting commuter parking lots, specifically the number of cars entering with 1, 2, 3, 4, or 5 occupants (including driver), and the same for cars exiting, plus the number of vehicles in the lot at the start and finish of the count.
- Vehicles entering the kiss-and-ride roadway.
- Passengers to and from the subway station via cars at the kiss-and-ride roadway.
- Numbers of vehicles dropping off and picking up passengers in the vicinity of the subway station, including the number of passengers to and from the subway station via these cars.
- Buses and bus passengers, recorded by bus, and summarized on the field sheet by 15- and 30-minute periods.
- Total persons walking into and out of the subway station.

Walk-in patrons are calculated, as part of survey processing, by taking the total persons walking into and out of the subway station and subtracting the patrons tallied in the other counts. As with TTC's other periodic special counts, traffic checker training includes use of an instruction booklet that indicates the purpose of the count and details procedures for filling out the field sheets. The Modal Split Count Program uses a separate field sheet design for each of the six count components. The TTC field sheet for vehicles and passengers entering and exiting commuter parking lots is reproduced in Appendix C as an example. Data entry is manual.

TTC publishes complete results including 15- and 30-minute passenger and vehicle counts by station, 15- and 30-minute parking lot accumulation by lot, various summaries, and historical comparisons by year. The survey does not obtain vehicle dwell time in the kiss-and-ride roadway. In the past, the WMATA has surveyed not only how many, but also how long vehicles wait in kiss-and-ride areas, as an aid to both future station design and development of kiss-and-ride area parking policy.

MARTA takes a parking lot occupancy count every Wednesday at 11:00 a.m. Once or twice a month the county of vehicle registration is observed and tallied. Results are averaged each month and are included in the monthly rail patronage report. The survey most recently has been used for monitoring a free parking promotion and for input to decisions with respect to parking fee modification.

Development-Related Ridership

WMATA in 1986 engaged a consultant to study the travel behavior of persons traveling to and from residential and commercial developments around Metrorail stations, to establish relationships between transit use and the nature of development at each site along with Metrorail station proximity. The count and survey used covered a sample of 34 building sites selected according to location within the region, type of development, and distance from the nearby station.

Depending on the nature of the development site and the degree of management cooperation obtained, employees, residents, visitors, and shoppers were surveyed with self-administered survey forms handed out by employers or survey staff, by personal interview at building entrances, or by telephone. A series of questions was asked, tailored to the category of person being surveyed. Employees, for example, received a questionnaire which covered in detail place of residence and employment, vehicle availability, socioeconomic characteristics, mode of travel to work, trip timing, parking cost, and mode, purpose, destination, and length of trips made from the workplace during the workday.

Each building was treated as one observation. The final coverage of the survey populations was in the 5 to 15 percent range. Completed surveys were factored up to the survey populations on the basis of counts or available information on numbers of employees, dwelling units, and persons entering and leaving the building. WMATA notes a need to enhance the data collection to increase the response rate in future surveys of this type. Survey data processing by the consultant was accomplished with a statistical software package.

STATION-TO-STATION SURVEYS

Station-to-station counts or surveys are designed to obtain information about a passenger's routing through a rail rapid transit system. A majority of operators report using station-to-station counts or surveys, but the only surveys for which detailed data were furnished in the synthesis survey were those specifically designed to obtain information required for UMTA Section 15 reporting.

Two operators report taking surveys for the primary purpose of obtaining trip length and unlinked trip data for the Section 15 Annual Report. A third reports a similar survey to obtain unlinked trip data only. In addition, in a letter to the NCTRP panel, the Port Authority Transit Corporation of Pennsylvania and New Jersey (PATCO) has provided information on how trip length is calculated from its stored-ride, entry/exit fare control system (*4*).

As noted in Chapter Two, trip length is required for computation of passenger mile statistics. Rail-to-rail transfers within the rapid transit system must be known in order to compute unlinked trips, the basic measure of patronage used in Section 15 reporting. MARTA and NYCTA are the two operators reporting combined trip length and transfer surveys. Each interviews a sample of riders on their station platforms to obtain the required information, but the overall approach is somewhat different, and the sample selection quite different. CTA surveys the occurrence of transfers only, preferring to compute trip length on the basis of on-board checks, as described earlier.

Field Survey Design

In the MARTA Rail Trip Length Survey, interviewers randomly select each fifth rider on the platform level of each station in each direction. Interviewers float in each direction on the cross-shaped rail system as they interview, East to West, North to South, and return. After interviewing each fifth rider on one station platform, they move on to the next. Interviews are conducted during each of six time periods: weekday a.m. peak, weekday base, weekday p.m. peak, weekday night, Saturday, and Sunday. The survey is scheduled from 6 a.m. to 10 p.m. over a 7-day period, twice a year.

NYCTA interviewers are assigned to one station control area, in other words, one fare-paid area, at a time. For a one-hour period, they interview as many people entering that control area as they can, usually about 100. Turnstile registers are recorded at the beginning and end of the hour, and non-turnstile users entering the control area are counted. The control areas and hours are randomly selected.

MARTA interviewers ask and record which station was used to enter the rail system, how the passenger will continue his or her journey after leaving the train (walk, transfer to train, or transfer to bus), and which station will be used to exit the system. NYCTA interviewers ask how many times the passenger will transfer and what is the last station he or she will use. NYCTA does not ask which station was used to enter the system, because by interviewing passengers entering the control area, it can be assumed that is where they enter the system.

The CTA survey takes place in November and April. CTA interview procedures are similar to those of NYCTA, however, an effort is made to interview passengers randomly. CTA interviewers do not ask about the exit station, but do ask the name or names of transfer stations, so that it can be verified that they are locations where barrier-free transfers can occur.

Sampling Design

Work assignments in the MARTA survey are designed to produce a sample of 3,700 interviews. MARTA estimates that with this sample they obtain an accuracy at the individual station level of ± 10 percent at the 95 percent confidence level, whereas the UMTA requires this rate only as measured at the systemwide level. Systemwide, the accuracy is estimated to be ±5 percent at the 95 percent confidence level. In expanding to the universe from the sample, the interview results are weighted to adjust for the level of patronage use at each station.

At NYCTA, the selection of control areas and hours is made from a pool of all the hours that each control area is open throughout the year. Approximately 500 control-area-hours are randomly selected. All fare paying and non-fare paying passengers within control-area-hour are counted and are candidates for interviewing.

The CTA survey is designed to produce 2,000 interviews. With data on number of transfers the sole objective of the survey, CTA estimates that this sample provides a systemwide accuracy of ± 1.6 percent at the 95 percent confidence level. The samples are stratified by weekday peak, weekday off-peak, and weekend, and are allocated to those three time categories proportionate to ridership. They are similarly stratified by rail lines proportionate to boardings by line. Rail stations where samples are taken are systematically selected to represent proportionate ridership within different segments of each rail line.

Management and Personnel

MARTA's Policy Planning and Budget Department is responsible for their rail trip length survey. Two supervisors, one technician, and 15 temporary personnel are used in the survey.

The NYCTA survey runs through the entire year. On a quarterly basis, systemwide figures are tabulated using computer-based spreadsheets, and an assessment of progress is made. Within NYCTA's Operations Planning Department, the Service and Ridership Data group selects the sample, Traffic Checking and Analysis runs the surveys, and Service and Ridership Data personnel calculate distances between stations for each trip documented by the interviewers.

The CTA survey is conducted by schedule checkers on temporary assignment to conducting interviews. The field effort requires 10 person-days.

Training and Quality Control

At MARTA, both training sessions and a pre-test are conducted prior to full-scale data collection. Emphasis is placed on the sampling procedure and familiarity with the survey instrument.

NYCTA checkers used in Section 15 data collection receive special training in addition to their regular training program. Totals for each one-hour sample, after entry into a computer-based spreadsheet, are checked for outliers based on the ranges of unlinked trips and passenger miles experienced in the past. Each year NYCTA computes actual variances, for sample trip length and unlinked trips, that are then used as feedback in adjusting the sample size for the next year.

CTA conducts a one-hour training session. Field supervision of interviewers is carried out each day.

Data Entry and Analysis

MARTA has converted from main-frame computer data analysis to personal computer processing of their rail trip length survey, using statistical software. NYCTA, as already noted, makes use of spreadsheets. Procedures for survey sample expansion to the universe of rail passenger trips were discussed above with reference to sampling design. CTA has used a data entry company under contract, but anticipates using hand-held data entry devices in the future.

PATCO circumvents the need for trip length surveys by using data from its graduated, stored ride, entry/exit control fare system to compute trip length (*4*). Unlike the information provided by BART's Data Acquisition System and Performance Monitoring System, which identify the exact station of origin and station of destination, PATCO's fare collection process only identifies destination by fare zone.

PATCO looks at each combination of fare zones, and starts with the total trips from each origin station to the destination fare zone. This is obtained from fare collection data. The total destinations within the destination fare zone are then allocated to each of the different stations within that fare zone. The allocation is proportional to the relative usage of the stations. This gives an estimate of the number of rides from each origin station to each of the destination stations within the fare zone combination, allowing average trip length to be computed. Completing the process for all combinations of fare zones allows average trip length for the system to be computed.

Data Reliability, Adequacy, and Cost

Surveys for obtaining the trip length and unlinked trip data required by the UMTA Section 15 Annual Report are designed specifically to meet or exceed the UMTA requirement of 10 percent accuracy at the 95 percent confidence level, as measured on a systemwide basis. UMTA's acceptance of the sampling plan and the resultant data is the test of adequacy. No operator reported major acceptance problems pertaining to count/survey trip length and unlinked trip data. The only cost breakout provided was for MARTA's 1989 Rail Trip Length survey, which was $5,000.

ORIGIN-DESTINATION SURVEYS

Origin-destination surveys obtain trip distribution data, which is to say that they not only provide a count of passenger trips, but also the spatial orientation of each trip. There are two levels of origin-destination data encountered in rail rapid transit surveys. There is information on station-level origin-destinations, where the station of origin and station of destination are identified, comparable to a "station-to-station survey," but not the primary origin or ultimate destination of the passenger's door-to-door trip. Then there are "true" origin-destination data, where the beginning and ultimate destination of the passenger's door-to-door trip are identified.

Origin-destination surveys typically are designed to obtain other information as well, within the limitations of the survey questionnaire or the time allotted for interviews. Origin-destination survey results allow operations planning and long range planning to be done with an understanding of how the rail rapid transit system and the trips its passengers are making relate to one another. They also meet the other special needs for which they are designed, such as market analysis. A more extensive discussion of survey purposes is found in Chapter Two.

Table 11 identifies the primary characteristics of the reported rail rapid transit origin-destination surveys. Detailed information is available on the six surveys that are examined here. One, the MARTA survey, is conducted by means of interviews. The others are self-administered, which means that the passenger is asked to fill out a questionnaire, or at least carry the survey instrument from one place to another. The majority are multi-purpose; the two TTC surveys are focused on questions of more limited scope.

TABLE 11

CHARACTERISTICS OF REPORTED RAPID TRANSIT ORIGIN-DESTINATION SURVEYS

Operator	Year of Survey	Nature of O-D Data	Method of Administration
BART	1987	"True"	Self-administered
MARTA	1985	Station level	Interview
NYCTA	1990	"True"	Self-administered
SEPTA	As required	As required	As required
TTC-1	1978	Station level	Self-administered
TTC-2	1981	"True"	Self-administered
WMATA	1987	Station level	Self-administered

TTC-1: Subway System Origin-Destination Survey.
TTC-2: Origin-Destination Survey of Parking Lot Patrons.

The WMATA's "Metrorail Passenger Survey" has been taken each one to three years, with refinements, since 1977. It is used here as the primary example for the purpose of comparisons among surveys.

Field Survey Design

All of the origin-destination surveys cover either the full operating day or from about 5 a.m. to 10 p.m. In the WMATA self-administered survey, questionnaires were distributed at each station on the system to the selected sample of patrons as they entered the fare-paid area. The survey was limited to Tuesdays, Wednesdays, and Thursdays, and ran from late April to early June. Several stations, picked by random selection, were surveyed on each day. Boxes for patrons to slip completed returns into were placed near each Metrorail exit throughout the system, and the survey card could also be mailed back, postage prepaid.

All WMATA questionnaires were numbered serially, and at each station mezzanine, the serial number to be handed out next was recorded on special forms each hour. A faregate readout was obtained at the attendant's kiosk at the beginning and end of the operating day, and at the break points between the a.m. peak period, midday period, p.m. peak period, and evening period. These were used for survey factoring.

The NYCTA and TTC survey hand-out and control procedures were similar to those of WMATA. However, instead of using serial numbers, TTC pre-coded its punch-card survey instruments by station of entry and time period, in addition to having separate colors for the a.m. rush, midday, p.m. rush, and evening periods. TTC survey cards were collected at each destination station; that is how the station of exit was identified, so no optional means of survey card return were provided.

In BART's 1987 survey, surveyors were stationed on selected train cars to hand out and collect their self-administered survey questionnaires. BART did this, along with shortening their questionnaire, in an effort to achieve a higher response than in previous surveys. A return rate roughly 25 to 50 percent higher than in previous surveys was achieved.

MARTA ran the one interview survey, conducted on both bus and rail vehicles throughout the system. Interviewing covered all days of the week. The average interview was completed in 10 minutes.

There are situations when an "on the shelf" survey design unquestionably serves best. Immediately after the Loma Prieta earthquake in 1989, BART was able to use their 1987 survey design to enable fielding a survey with only two to three weeks lead time. With the San Francisco-Oakland Bay Bridge closed for a month, this gave BART a snapshot of what they considered to be the latent demand for their trans-bay service. Consistency of survey design is one objective to consider even under normal circumstances, in that it enhances comparability of data.

Survey Instrument

The design of the origin-destination survey questionnaire, known as the survey instrument, is crucial to ensure that the desired information is obtained. In the case of a self-administered survey, there is little opportunity for explanations. The questionnaire must be simple and clear enough for the respondents, who will have varying levels of education, experience, and English language capability, to understand and be able to answer in a manner which is useful.

The questionnaire must be short enough that respondents do not give up on it. In an interview survey, the list of questions must be simple and short enough for survey completion within the time allotted. Multiple-choice questions predominate in all of the self-administered and interview survey instruments.

Figure 4 shows the questionnaire used in WMATA's 1987 Metrorail Passenger Survey. Table 12 identifies the nature of information sought in each question asked on any one or more of the six surveys examined here. A check-mark indicates which questions were covered on each survey individually. The word "known" indicates that, even without asking, the information was known either by virtue of the study design, or in the case of the MARTA survey, could be observed by the interviewer.

All of the origin-destination surveys, aside from the specialized TTC "Origin-Destination Survey of Parking Lot Patrons at Subway Stations," identify the station of origin and the destination station, providing station-level origin-destination data at a minimum. The complexity ranges from the BART survey, which asked a total of 22 basic questions plus several subsidiary questions, to the TTC "Subway System Origin-Destination Survey," which asked only that the rider tear off the appropriate corner of the punch card to indicate his or her transfer station. All the TTC patron had to do to identify his or her origin station and destination station was to carry the card from one place to the other. The BART and TTC survey forms are reproduced in Appendix C.

Each survey can be thought of as having two parts, with part one focusing on origin-destination data and part two being designed to meet other survey objectives. Part two of the BART survey seeks to learn about the patron's commuting habits, socioeconomic characteristics, and type of fare paid on all transit segments of the trip. The MARTA survey explores transit pass usage, the perceived quality of transit service, and advertisement penetration. The NYCTA survey, along with fare and socioeconomic questions, asks details on transfer stations and individual subway routes used. The TTC systemwide survey focuses on what transfer stations are used, while the TTC parking lot patron survey seeks to determine if the parking lot patrons are using the subway and how long they are parked. The WMATA survey inquires about why patrons who drive to Metrorail are not using a feeder bus, and asks jurisdiction and precise location of residence, for use in subsidy allocation.

The compact WMATA survey instrument, structured around a philosophy that too many questions lead to non-response and incompleteness, contains most of the basic origin-destination, mode of access, trip purpose, and fare payment questions asked on the longer surveys. The notable omissions are the "true" origin or destination, and any socioeconomic data, the lack of which constrains somewhat the travel demand modeling uses to which the data can be put. As noted in Table 11, the BART and NYCTA surveys, along with the TTC parking lot survey, do obtain "true" origin and destination data.

As can be seen in Figure 4, the WMATA survey first asks about activities prior to the Metrorail ride, then about activities after the Metrorail ride, and finally miscellaneous questions. This ordering, common to several surveys, helps improve survey clarity. Trip purpose is asked in "purpose from" (Question B) and "purpose to" (Question G) format, which allows translation into standard travel demand modeling trip descriptions, such as "home-based work," "home-based other," and "non-home based." All of the U.S. surveys do this.

A classic station/mode/purpose/place ordering of questions to get a proper response to "true" origin and "true" destination in a self-administered survey is followed by the BART survey, with only a slight variation in the NYCTA survey. Note the logic flow in this classic ordering:

- Which station did you enter?
- How did you get to this station? (Walk, Taxi, etc.)
- Where did you come from? (Home, Work, School, Shopping, etc.)
- Where is the location of this place that you came from? ("True" origin)
- Which station will you exit from?
- How will you get from this station to your destination? (Walk, etc.)
- Where are you going? (Home, Work, etc.)
- Where is the location of this place that you are going? ("True" destination)

By first working back from the station of entrance, and then forward from the exit station, the question ordering helps the respondent understand what is being asked. In particular, asking about the station of entrance before asking about the "true" origin helps the respondent know that "place that you came from" is intended to be something different from where he or she got on the train, and the same for station of exit vis-a-vis "true" destination.

Sampling Design

There are three key questions to be addressed in establishing how many questionnaires should be handed out in a self-administered survey. First, the sample size required to meet survey objectives must be determined. Second, the rate of return of completed, valid questionnaires must be estimated. The pro-

METRORAIL PASSENGER SURVEY

Please take a minute to help us in planning for your transit needs by completing this survey questionnaire. ***Please return the questionaire in the box you will find near the exit gates*** or simply drop it in any mailbox—no stamp necessary.

*Please fill out this survey card **each** time you receive one.*

№ 238924

A. At which Metro station did you RECEIVE this card?

B. Where did you come from just before ENTERING the Metro station where you RECEIVED this card? (check one)
1. ☐ Work
2. ☐ Home
3. ☐ Job-related business
4. ☐ Shopping or meal
5. ☐ School
6. ☐ Personal Business
7. ☐ Sightseeing or recreation
8. ☐ Other (specify ______)

C. How did you get to the Metro station where you RECEIVED this card? (check one)
1. ☐ Metrobus. Rt.# ___
2. ☐ Ride-On
3. ☐ Fairfax Connector.
4. ☐ CUE
5. ☐ Alexandria DASH
6. ☐ Auto Driver
7. ☐ Auto Passenger
8. ☐ Taxi
9. ☐ Bicycle
10. ☐ Walk
11. ☐ AMTRAK or MARC
12. ☐ Other (specify ______)

D. If you arrived by auto, please indicate the MOST IMPORTANT reason you did not use the bus. (check one)
1. ☐ Cost too much
2. ☐ Bus trip too long
3. ☐ Bus stop too far from home
4. ☐ Doesn't operate when I need it
5. ☐ Waiting time for bus too long
6. ☐ Need car for other trips
7. ☐ Not familiar with bus system
8. ☐ Don't like riding bus

E. What type of fare did you pay to ENTER the Metro station where you RECEIVED this card? (check one)
1. ☐ Regular fare
2. ☐ School fare
3. ☐ Elderly/handicapped
4. ☐ Flash Pass
5. ☐ WMATA Employee or Police

F. At which METRO station will you LEAVE the Metrorail system on this ONE-way trip?

G. Where will you go just after LEAVING the Metro station? (check one)
1. ☐ Work
2. ☐ Home
3. ☐ Job-related business
4. ☐ Shopping or meal
5. ☐ School
6. ☐ Personal Business
7. ☐ Sightseeing or recreation
8. ☐ Other (specify ______)

H. How will you get to this destination after LEAVING the Metro station? (check one)
1. ☐ Metrobus. Rt.# ___
2. ☐ Ride-On
3. ☐ Fairfax Connector.
4. ☐ CUE
5. ☐ Alexandria DASH
6. ☐ Auto Driver
7. ☐ Auto Passenger
8. ☐ Taxi
9. ☐ Bicycle
10. ☐ Walk
11. ☐ AMTRAK or MARC
12. ☐ Other (specify ______)

I. How would you have made this trip if Metrorail were not available? (check one)
1. ☐ Bus
2. ☐ Auto
3. ☐ Taxi
4. ☐ Would not have made this trip
5. ☐ Other (specify ______)

J. Where do you live? (check one)
1. ☐ District of Columbia
2. ☐ Montgomery County
3. ☐ Prince George's County
4. ☐ Anne Arundel County
5. ☐ Baltimore City/County
6. ☐ Charles County
7. ☐ Frederick County
8. ☐ Howard County
9. ☐ Arlington County
10. ☐ City of Alexandria
11. ☐ Fairfax County
12. ☐ City of Falls Church
13. ☐ Fairfax City
14. ☐ Loudoun County
15. ☐ Prince William County
16. ☐ Stafford, Spottsylvania, Fredericksburg, Va.
17. ☐ Outside the Washington area

K. What is your home address and zip code?

number ______ street ______ zip code ______

Thank you for riding Metro and completing this survey!

FIGURE 4. Washington Metropolitan Area Transit Authority Self-Administered Origin-Destination Survey Questionnaire.

TABLE 12

QUESTIONS ASKED ON RAIL RAPID TRANSIT ORIGIN-DESTINATION SURVEYS

Questions Asked: Operator/Survey:	BART	MARTA	NYCTA	TTC-1	TTC-2	WMATA
Station of entry	√	√	√,known	known		√,known
Mode of access	√	√	√		√	√
Auto mode of access parking/drop-off details	√				√	
Transit mode of access route/fare details	√					
Reason for not using bus instead of auto access						√
Time/hour of day		known	√,known			known
How time of arrival was decided	√					
Station of boarding train		known				
Rail route		known	√			
Direction (inbound/outbound)		known				
Trip purpose (at origin)	√	√	√			√
Main purpose of trip					√	
Trip purpose (destination)	√	√	√			√
Address (or equivalent) of origin	√		√		√	
Address (or equivalent) of destination	√		√		√	
Station of exit	√	√	√	known		√
Mode of egress	√	√	√			√
Auto mode of egress parking/pick-up details	√					
Transit mode of egress route/fare details	√					
Rail-to-rail transfer station(s) used			√	√		
Rail route(s) transferred to			√			
Transit modes used and total transfers required		√				
Use of rail rapid transit for trip (yes/no)					√	
Trips taken/to be taken on rail that day	√					
Mode of travel in other direction if applicable	√					
Type of rail fare used	√	√	√			√
Eligibility for E&H reduced fare		√				
Location of transit pass purchase		√				
Frequency of transit pass usage		√				
Frequency of rail rapid transit use	√	√	√		√	
Length of time rail rapid transit used	√					
Prior or alternate mode		√				√
Rail rapid transit on-time performance	√					
Opinion of overall service quality		√				
Opinion of courtesy, safety, crowding, etc.		√				
Radio station listened to most frequently		√				
Newspapers read often		√				
Have heard transit advertisement on radio		√				
Have read transit advertisement in paper		√				
Auto availability for trip	√	√				
Auto ownership	√					
Age	√	√	√			
Sex	√	known	√			
Race/ethnic group		known	√			
Employment status	√					
Household income	√	√	√			
Number of persons in household	√					
Jurisdiction of residence						√
Home address or equivalent			√			√
Comments	√				√	

TTC-1: T.T.C. Subway System Origin-Destination Survey.
TTC-2: Origin-Destination Survey of Parking Lot Patrons at Subway Stations.

portion of questionnaires handed out that are actually returned with usable information is something that survey designers can influence, but cannot directly control. Third, the rate at which questionnaires should be handed out must be determined. The handout rate must be such that, combined with the expected valid return rate, the desired sample size is obtained.

The size of the WMATA survey sample is keyed to obtaining the desired accuracy of information on rider jurisdiction of residence, because that information is used in subsidy allocation, and is the survey's primary reason for being. WMATA requires an accuracy of ± 0.5 percent at the 95 percent confidence level for jurisdiction of residence systemwide, and ± 10 percent at the 95 percent confidence level for jurisdiction of residence as measured at any given station during any given time period. For the 1987 survey, a worst case assumption was used: that the statistically critical jurisdiction accounted for half of all ridership.

These requirements resulted in an estimated sample size of 38,500 valid questionnaires returned overall, and 100 responses per station per time period. A 38 percent questionnaire return rate was anticipated and achieved. The approach adopted has been to hand out questionnaires to 100 percent of all patrons at stations and time periods with fewer than 1,000 entering passengers, and to hand out questionnaires to 1 out of 4, or 25 percent, of all entering patrons at other station/time periods. The time periods referred to here are a.m. peak, midday, p.m. peak, and evening.

Table 13 summarizes available information on questionnaire handout and return rates for the self-administered surveys. The return rates given in Table 13 are for the overall return rate; the rate of usable returns is always somewhat less. The highest return rate was achieved with TTC's very simple punch-card format.

BART's 1987 sample size was based on a requirement to accurately estimate access mode and other station level characteristics by time of day. The survey produced 9,719 usable responses. For systemwide data, the maximum error was ±0.5 percent at the 90 percent confidence level. The 1989 post-earthquake survey used a reduced sample size.

The MARTA interview survey was designed to produce an accuracy of ± 10 percent at the 90 percent confidence level. This was estimated to require 3,000 responses across the bus and rail system. Almost 5,000 were obtained, a 1.5 percent sample. The sample was stratified by geography, mode, time of day, and direction to ensure a minimum number of responses in each category.

Survey factoring to compensate for handout and return rates is a critical step, discussed below with respect to both data analysis and data reliability. The survey factoring procedure must be fully detailed before sampling and field survey design can be completed. Otherwise, the survey procedures established may prove insufficient to the task of providing needed statistical and bias control.

TABLE 13

SELF-ADMINISTERED ORIGIN-DESTINATION SURVEY HANDOUT AND RETURN RATES

Operator and Survey Date	Riders Handed Forms (%)	Return Rate (% of Handout)
BART 1987	5-12	74
BART 1989 (1)	2	75
TTC 1975 (2)	89	87
TTC 1978 (2)	82	82
WMATA 1987	31	38

(1) Post-earthquake S.F. Bay Bridge closure survey.
(2) Both TTC surveys are subway system origin-destination surveys (not parking lot patron surveys).

Management and Personnel

WMATA contracts out its origin-destination survey. The survey was conducted by trained field staff working four- to nine-hour shifts, with guidance provided by a data collection manager and two technical advisors. Five to nine surveyors, plus two to three relief surveyors and one shift supervisor, were available for the 6 a.m. to 3 p.m. and 3 p.m. to 12 midnight shifts. The survey ran Tuesday through Thursday for seven weeks.

The other operators conducted their origin-destination surveys with in-house staff, hiring temporary personnel in some cases. Consultant advice on sampling and contract data entry services were likewise utilized by some operators. BART has found the on-train questionnaire handout procedure to be more labor intensive than entry gate surveys. Peak period trains required six to 10 surveyors for each one covered.

Training and Quality Control

A two-stage orientation and training program was employed in the WMATA survey. Initially, a half-day orientation session was conducted for management and supervisory level employees, with emphasis on WMATA past experiences and present expectations. Then, the day before commencement of field work, a more extensive training program was conducted for all field crew personnel. This included a field demonstration with WMATA staff participation.

As the survey progressed, returned questionnaires were coded and entered into a data file, allowing monitoring of the pass-out rate and response rate. As a result of these checks, a number of low volume station/time periods, all in the evening, were resurveyed during the final week of data collection. The data file records were machine-edited to check for illegal combinations of codes, and responses outside of the allowable range. In addition, Northern Virginia Transportation Commission (NVTC) staff verified jurisdiction of residence against address of residence in instances where respondents might confuse post office designation with actual jurisdiction of residence.

In New York, the time of day and route given on NYCTA survey responses were verified against the serial numbers used to control distribution. The feasibility of reported trip links was also tested. TTC, in Toronto, conducted a limited personal interview survey in the corridor used by passengers transferring at the Spadina Station complex to supplement their self-administered survey. Otherwise the volume transferring could have been determined only by subtraction, a dangerous practice in a statistical analysis. Tear-off corners had only been provided on the punch-card survey instrument for the other two possible transfer locations.

MARTA had different training and quality control requirements because of using interviews instead of a self-administered survey. Interviewers were extensively trained, provided with written questionnaire instructions, and required to be functionally knowledgeable about the MARTA system.

Data Entry and Analysis

Data entry of WMATA origin-destination survey returns was accomplished preparatory to validation, as described above. Validated responses were weighted by data expansion factors derived for each of the 244 possible combinations of origin station and time period. These factors expand the survey results to represent actual ridership as obtained from faregate entry data.

A major end product of the analysis was a standard machine-readable listing or "file" of all completed survey records along with their associated expansion factors. This survey file remains available for analysis by WMATA, the Metropolitan Washington Council of Governments, and others. The contractor was also responsible for producing a number of cross tabulations and special tabulations of immediate interest to WMATA and local planning agencies from the factored data. A statistical analysis software package was employed.

Expansion of the TTC system survey was nearly identical, using 224 station/time combinations as the basis for expansion factors. MARTA similarly factored their interviews by mode, direction, and time of day. BART has the advantage of their Data Acquisition System for expansion of valid survey returns to the total population of riders. The station-level origin-destination data produced at two minute increments by BART's entry/exit control fare system allows factoring of origin-destination survey data by origin-destination station combination and time period, effectively controlling for potential trip length bias and for geographic biases associated with socioeconomic and land use influences at both ends of the trip.

Data Reliability

Self-administered surveys will always be subject to the concern that response biases have skewed the data obtained. Even with the fine-grained factoring made possible by their Data Acquisition System, BART notes in their survey report that differences in response rates between the surveys they have taken may affect comparisons between the surveys. They suspect that those passengers who travel less frequently may be less likely to respond, and feel this may in part explain the higher proportion of less frequent travelers and non-work trip purposes in their 1987 survey results, which benefit from a higher response rate than before.

The operators covered by the synthesis survey did not report any exhaustive examination of potential biases in self-administered rapid transit surveys. A detailed study of a self-administered transit survey covering the Washington, D.C. area's pre-Metrorail bus system found strong potential biases related to time of day, direction of travel, route, and route segment that would have severely warped the results had not the individual strata been differentially factored (*5*). The potential biases appeared to be largely related to socioeconomic factors. Higher response rates tended to be associated with higher income areas of the city, with commuting into the central business district, and with longer trips. Lower response rates were associated with the converse, including commuting from the city to the suburbs, and off-peak travel, which may be assumed to consist more of captive riders than peak period commuting. Language barriers can also produce biases in areas with large populations of non-English speakers.

Table 14 lists the proportion of valid returns obtained in the WMATA Metrorail survey by time period. The potential bias related to time of day can clearly be seen. It can be calculated that without differential factoring, a.m. peak period trips would be overrepresented by 22 percent on average systemwide, and evening trips would be underrepresented by 23 percent. Factoring by individual station and time period is a minimum requirement, and it may be surmised that the ability to factor by station combination that is available to BART is of significant added benefit.

The trade-off between self-administered surveys with their potential for biases and interview surveys is cost, and the impact of cost on sample size. The self-administered surveys produce larger samples per dollar cost, avoiding some of the analytical constraints imposed by small-sample surveys.

Data Adequacy and Cost

The origin-destination surveys reported on here have been used, with apparent success, for the specific purposes for which they were designed. They also appear to have met a broad variety of information needs not only for the rail rapid transit operators, but also for regional and local planning organizations. Their use for long range systems planning, whether by the operator or by regional planning organizations, is significantly enhanced if "true" origin and destination data are collected and geocoded to provide information on the complete door-to-door trip.

The WMATA survey costs $150,000 each year it is taken. In intervening years, WMATA staff updates critical values on the basis of faregate tallies. To date this has been done using station faregate entries alone. To conduct this data maintenance on the basis of both faregate entries and exits, WMATA has estimated an annual staff cost of $75,000. The BART 1987 origin-destination survey cost $51,000. The MARTA on-board interview survey costs $40,000-$50,000 for bus and rail combined. These costs should be taken in context with the sample sizes discussed above under Sampling Design.

TABLE 14

WMATA ORIGIN-DESTINATION SURVEY RESPONSE BY TIME PERIOD

Time Period	Forms Passed Out	Valid Returns	Valid Return Rate (%)
AM Peak	47,318	19,417	41
Midday	32,769	9,739	30
PM Peak	41,678	13,260	32
Evening	20,895	5,428	26
TOTAL	142,660	47,844	34

Note: Valid return rates are less than overall return rates as given in Table 3.6, because unusable returns are excluded.

BART initially allocated $130,000 for a 1990 survey, to provide a larger sample than in the 1987 survey. There is concern at BART that "lumpiness" in the sample produced by handing out survey questionnaires only on selected trains adversely affects the universality of the survey results. Circumstances intervened, and BART instead cooperated with the Metropolitan Transportation Commission's 1990 regionwide travel survey, enriching the sample with 1,000 transit users who volunteered their name, address, and phone number in the 1989 BART survey. In the future, BART may return to handing out origin-destination survey questionnaires at stations instead of on trains, for reasons of cost and sampling concerns.

FARE SURVEYS

Surveys related to the collection and setting of fares fall into two basic categories, fare mix surveys and user surveys. Fare mix surveys are conducted to find out the relative use of the different types of cash fare payment that result in the cash revenue take of the system. User (and non-user) surveys taken for purposes of fare analysis are conducted to find out about user needs and responses to fares already in place, especially new and innovative fares, and to explore the possible market response to changes in fares and fare systems.

As was done with station activity counts, fare surveys are covered here one type at a time. After addressing fare mix surveys, several different types of user surveys are individually discussed.

Fare Mix Surveys

Fare mix surveys involve counting the numbers of passengers using each available type of fare payment. These surveys may cover either all fares paid to enter the rail rapid transit system, as in the MBTA survey, or just the fares paid to an agent, as in the TTC's "Cash Fare Count." In either case, this information is necessary in order to convert the total amount of cash revenue collected to numbers of passengers, both in total and broken down by the different available fare media.

At MBTA manual counting is conducted at collectors' turnstiles and gateperson's boxes. The regular turnstiles, when functioning properly, provide the necessary data on token and prepaid-pass usage. Traffic checkers record regular turnstile readings as a backup to MBTA's normal turnstile data collection. They count the number of people passing through the collectors' turnstiles, by method of fare payment, and do the same for gateperson's boxes. Collectors' turnstile readings are also recorded. Annual survey costs for the entire bus and rail system are $30,000.

At TTC, although the emphasis is on cash fares, pass utilization is also counted. Details on use of bills for fare payment are also entered on the survey forms. This information is used to determine the supply of coins to station collectors. The TTC field sheet is reproduced in Appendix C. MBTA and TTC both enter fare mix survey data manually, but TTC plans conversion to optical scanning.

Both surveys cover all days of the week. MBTA surveys are taken at random over a six-month period. The manual survey at collector's turnstiles and gateperson's boxes covers a sample of 1,500 entries into the rapid transit system. Turnstile data is in addition. TTC takes a 10 percent sample during January to March and September to November. MBTA estimates that their sample gives a systemwide accuracy of ±2.5 percent at the 95 percent confidence level. This accuracy estimate applies to the fare mix, and thus to revenue based ridership estimates prepared using the fare mix, on a systemwide basis.

Fare Media User Surveys

The CTA's "QuickPass User Surveys" provide an example of surveys taken to gauge ridership reaction to a new fare media—or a new anything, for that matter—and to identify problems and areas for improvement. CTA handed out self-administered questionnaires to QuickPass purchasers in both 1987 and 1988, in connection with demonstration project implementation of these magnetically encoded unlimited ride passes.

The questionnaire in the first survey covered the following: ease, location, and frequency of pass use; time savings afforded by the QuickPass; problems; pass durability; adequacy of instructions; and reasons for pass purchase. For example, one question asked if the card was O.K., too thin, too thick, too messy, too stiff, not durable enough, and if the printing came off. Socioeconomic and general transit use questions were also asked. In the second survey, defects in the construction of the QuickPass having been resolved, respondents were asked instead about their preference between the QuickPass and the regular pass, and given more space for comments.

The QuickPass User Survey return rate was 15 percent for the first survey and somewhat less for the second survey. CTA staff judged that regular users had the highest return rate, perhaps as high as 40 percent or so. If the purpose of the survey had been to quantify some aspect of ridership for which data reliability was a big concern, the obvious bias would undoubtedly have been unacceptable. However, for troubleshooting and finding out that practically everybody liked the QuickPass, the survey met its objectives.

Trip Diaries

The Market Analysis and Research section within CTA's Department of Strategic Planning also conducted a pass-related survey that included a trip diary survey element. Two separate questionnaires were developed, one surveying users of pre-paid, unlimited ride passes, and the other directed at cash-fare payers and token users. Both surveys were similar, gathering information about travel patterns, socioeconomic characteristics, pass purchase habits, monetary costs of traveling on the CTA, and preferences for alternative types of passes.

The travel pattern questions were structured in one-day trip diary format, meaning that the respondent was asked to provide information on each trip taken during the day. This allowed comparisons to be made between pass purchasers and cash/token payers with respect to their transit usage. Filling out the trip diary under self-administered survey conditions apparently posed a problem for survey respondents. The percentage of trip diary logs that were usable constituted between a half and two-thirds of the survey forms returned. Statistical tests were performed on the tabulated survey responses to identify those differences between pass users and non-users that were statistically significant.

Stated Preference Surveys

A stated preference survey can contribute to decisionmaking when past or current passenger response to fares and fare changes does not provide enough information about how patronage might respond to new types of fares under consideration. The same holds true for other types of transit service changes. Stated preference surveys are not simple "what would you do if" questionnaires, which have been largely discredited owing to their notorious inability to obtain reliable projections of behavior in response to changed conditions. They use carefully structured sets of comparative questions, the responses to which are best analyzed within a probability modeling framework. Even so, estimates based on stated preference survey results should not be used in isolation from other indicators of likely outcome.

CTA used two stated preference surveys in estimating the effect of a full range of fare structure modifications on different existing and potential ridership market segments. In the first survey the questionnaire design included stated preference trade-off "experiments" which asked the respondent to choose between pairs of descriptions of varying service levels and fares for transit and auto alternatives. In this manner, as the respondent selected a preferred travel mode under the conditions described, several different fare levels were being tested. Mail-back self-administered survey forms were distributed at places of work to both CTA users and non-users. Despite refinements based on extensive pilot surveys, the return rate achieved was not particularly good. Of 6,000 questionnaires distributed at 25 employment centers, 1,100 were returned. Also, a sample of 896 non-work riders was interviewed at 25 activity centers such as shopping malls.

Using a statistical software package and a statistical curve-fitting program, modal choice sensitivities to fare variation were derived for several different market segments. This information was then used in conjunction with 1979 origin-destination survey and 1980 Census Journey to Work data to formulate a travel demand model for estimating the ridership impacts of the fare structure options under study — an example of using both transit and regional planning survey data together to meet an analytical need.

A second model was used in a "Consumer Based Fare Structures and Program Design" study which assisted CTA in formulating alternative fare structures and selecting a specific structure for implementation in 1990 (*6,7*). After implementation, system total ridership was within 1 percent of the modeled estimate, and 0.6 percent above the projection. Subdivisions of the total varied more from the estimate, as would be expected. Full fare riders were 3.2 percent more than estimated, whereas reduced fare riders were 10.4 percent less. The Transit Price Evaluation Model (TPEM) included a "payment method market share" developed from an 800-sample stated preference telephone survey. TPEM was used to estimate the number of individual full fare and reduced fare payment options and the revenue impacts. The survey was embedded in the TPEM. Difficulties were encountered with certain submarkets, with full fare pass use tending to be underpredicted, but the total results were within the range of sensitivity analysis findings. The evaluative analyses were successful in aiding the choice of a fare structure that generated a 6 percent revenue increase with less than a 1 percent unlinked ridership loss during the post-implementation study period. Ridership for the year containing the fare change was up slightly. For continued use of the TPEM, the CTA staff recalibrated the payment method and market share equations based on their experience with the model.

COSTS

Information on rail rapid transit system ridership data collection and application costs is typically difficult to isolate from other budget items. Costs of individual data collection efforts within a department are frequently not segregated from the costs of other activities, data collection or otherwise, within the same department. Often it is only those surveys that are contracted out that can be explicitly identified with a cost. When total data collection costs are available, there is frequently no breakdown between the rail rapid transit related and surface transit related activities in multimodal operations. Overhead and other cost allocation questions mean that all cost information has to be accepted with less than full confidence in its transferability from one operator to another.

Be that as it may, cost data for specific surveys that could be extracted from the survey have been presented in the preceding discussion. They should be used with due caution.

Systemwide ridership data collection costs provided in the survey are given in Table 15. The annual cost per ride (unlinked trip) is less than one cent in all cases, with indication of a strong economy of scale with increasing system size. Note that the cost information in Table 15 for the MDTA and the NYCTA includes bus costs and bus passenger trips. MDTA unlinked trips are 16 percent rail rapid transit, and NYCTA unlinked trips are 69 percent rail rapid transit.

TABLE 15

SYSTEMWIDE PASSENGER DATA COLLECTION AND ANALYSIS COSTS

Operator	Annual Cost	Operation and Items Covered	Cost per Rider
BART	$225,000	Rail rapid transit (1)	0.35¢
GCRTA	$75,000	Rail (load and turnstile)	0.95¢
MBTA	$175,000	Rail rapid transit (2)	0.11¢
MDTA	$350,000	Bus and rail system total	0.47¢
NYCTA	$2,833,000	Bus and rail system total	0.12¢
SEPTA	$68,500	Rail rapid transit (3)	0.07¢
WMATA	$325,000	Rail rapid transit (4)	0.18¢

(1) Data Acquisition System plus 1987 O-D survey cost spread over two years.
(2) Excludes annual boarding counts; may include some costs for non-rapid-transit modes.
(3) Estimated bus/rail allocation; excludes turnstile counts.
(4) Load counts, faregate counts, plus O-D costs (including certain projected entry/exit analysis costs) and station area count costs averaged over three years.

CHAPTER FOUR

NEW DIRECTIONS

Some of the available literature on the subject of collection and application of rail rapid transit ridership data implies a major thrust toward hardware solutions in the form of video cameras, passenger load weighing devices, and other equipment to facilitate passenger counting in and of itself (*8*). In contrast, in responding to the synthesis survey, only one operator expressed interest in automatic passenger counters for rail rapid transit ridership data collection. There was no mention at all of approaches such as video technology. Instead, interest in new and improved passenger data collection solutions appears to be taking the following directions:

- Replacement or enhancement of hand counting or tallying in those specific applications where technology can be employed to better collect both fares and passenger data concurrently.
- Improvement of the interface between the human observer and computerized data analysis, through use of hardware and procedures that expedite data entry, and may also enhance hand counting.
- Facilitation of data analysis, by replacing manual calculations with computer software, enhancing existing software, and locating data processing on more accessible personal computers.

Accordingly, current or forthcoming development programs described in the synthesis survey responses or followup interviews are reported on here under the headings "Improving Fare/Data Collection," "Improving Data Entry," and "Improving Data Analysis." Where existing procedures and equipment employed by individual operators today might be considered major "new directions" by other operators, reference back to the applicable discussion in Chapter Three is made. After the program descriptions, research recommendations made by survey respondents are listed.

IMPROVING FARE/DATA COLLECTION

A rail rapid transit fare collection system can be designed to provide the vast majority of passenger data now collected by counts and surveys, as demonstrated by BART's "Data Acquisition System" and "Performance Monitoring System," operated in conjunction with automated entry/exit fare collection. Although the passenger data collection potential of entry-only fare collection systems is more limited, there are possibilities for real-time passenger counting by fare category that have not been realized through traditional fare collection.

Automated Fare Collection

NYCTA has an Automated Fare Collection project underway to convert from tokens to fare cards. This will be an automated entry-only fare collection system. CTA is beginning automated entry-only fare collection planning. MDTA and MARTA have staged programs for coupling their existing turnstiles with data storage and transmission capabilities.

SEPTA recently has installed automated entry-only fare collection equipment throughout Philadelphia's subway/elevated system. Both turnstiles and cashier consoles are connected to "booth computers" located in the station. These computers are in turn connected to a central host computer. The turnstiles accept coins including Susan B. Anthony dollars, adult tokens, and passes read with a slide reader. Special fares are handled by the cashier.

With respect to passenger data collection, the new SEPTA system records each individual passenger entry, whether via turnstile or cashier, along with information on the fare paid. For example, when a pass is used, the type of pass, pass serial number, and time are recorded. Passenger/fare data are stored in the booth computer, and selected information will be reported to the host computer on at least an hourly basis when installation is complete. Host computer software is designed to provide reports daily.

Fare collection equipment like that purchased by SEPTA is flexible in terms of what entry-only information is obtained, how much is transmitted to the host computer, and how frequently. The turnstiles and cashier consoles are equipped with E-proms (erasable-programmable read-only memory chips) that can be programmed with the desired instructions. The booth computers, and obviously the host computer, can be programmed as desired. Capacity for data transmission to the host computer is a limitation to be dealt with, and the extent and frequency of ridership data transmission which is possible will in part be a function of the priority assigned to it as compared to other data transmissions.

The BART Data Acquisition System was covered in Chapter Three under "Entry/Exit Faregate Tallies." Aside from obsolescence of some of the computer hardware, the BART automated fare collection system and associated software represents the state of the art for fully automated rail-mode-only passenger data collection and analysis in connection with entry/exit fare collection. The "Universal Ticket Program" described below is an extension of those capabilities to multi-modal fare and passenger data collection.

Universal Ticket Program

The Universal Ticket Program in the San Francisco Bay Area is a demonstration project funded by UMTA and the Metropolitan Transportation Commission (MTC) to develop the hardware and software required to provide regional multi-mode, multi-operator transit rides with just one ticket. BART, other San

Francisco Bay Area transit operators, and MTC are participating in the program. Primary objectives are to facilitate joint fares among area bus and rail systems, and to provide ridership data needed for revenue sharing and market research. In the process, BART will be provided with linked trip data for bus to rail transfer trips, complementing the station to station origin-destination data available from the BART entry/exit fare control system.

The first phase involves implementation of a joint ticket covering the BART rail system, Central Contra Costa Transit Authority (CCCTA) bus service and BART Express Bus service. This joint ticket will use stored-value ticketing as is used on BART. It will allow a single ticket to be used on all three systems. Later phases will expand the joint ticket to include other operators.

Three projects are involved in the initial phase. The first is development and installation of bus ticket validators for approximately 150 CCCTA and BART Express buses. These validators will be capable of reading magnetic-strip stored-value tickets, deducting a full or discounted fare, and printing the remaining value. Ridership and other information will be stored on portable data storage modules which will be removed weekly for transfer of data to a central computer. The on-bus validators will provide a function equivalent to a BART faregate, subtracting fares in an amount which depends on whether a connecting bus or BART trip is taken. The equipment will keep track of where tickets are used to facilitate revenue sharing.

The second project provides a system of distribution for the bus/rail stored-value tickets. A total of 24 automatic vendors capable of dispensing the universal ticket will be installed at 15 BART stations. The vendors will accept cash, credit cards, and ATM debit cards, and will be controlled by a central computer which will capture detailed data on sales and operations. The third project will cover modifications to those BART faregates which do not already accept joint tickets. The total demonstration project has a cost of $5.8 million for the initial phase, and is expected to be completed by 1993, including one year of trial operation.

IMPROVING DATA ENTRY

Manual entry of data collected manually in the field can be a bottleneck in processing information. In addition, manual data entry introduces further potential for error and higher personnel costs. Two possible options for data entry automation are offered by hand-held data entry devices and optical scanning.

Hand-Held Data Entry Devices

Hand-held data entry devices, or hand-held computers (Figure 5), saw use in bus ridership data collection before application in the rail rapid transit environment. They have now been purchased by CTA, MDTA and MARTA, and are being purchased or considered for purchase by other rail rapid transit operators. These devices allow entry of alphanumeric data in the field which then can be read directly into compatible computer equipment in the office. Manual data entry is completely circumvented.

CTA has had their hand-held data entry devices in use for a number of months; their experience in using the devices was

FIGURE 5. Micro-Wand III Hand-Held Entry Device (Micro-Wand III is a registered trademark of Hand Held Products, Inc.)

covered in Chapter Three under "On-board Checks." CTA purchased units featuring an alphanumeric keyboard, a bar code reader, four function keys, and a two-line screen for data display. The device in Figure 5 has a partial alphanumeric keyboard.

CTA engaged their vendor to program the hand-held units along with a data base program used to prepare downloads of count format data from a PC into the device, and a program used in uploading field data from it into a PC. The total cost for four units, peripheral equipment, programming, and a two-year service agreement was on the order of $20,000. CTA staff prepared a macro program used for data analysis, the station data required for downloading into the hand-held device, and station-to-station distance data for the analysis program.

CTA staff evaluated six hand-held data entry devices before making their choice (*9*). In their selection process they considered weight, data storage capability, display screen capacity, display screen legibility, battery life, ease of battery replacement, ability to operate under a full range of weather conditions, and cost. They also wanted a device that is "not very useful unless it is hooked up to the office computer," as field personnel are instructed to say to curious onlookers, who might conceivably be considering theft.

CTA specifically asked for programming that would not only allow field personnel to see results as they went along but also allow corrections in the field. Operators with greater concern about auditability could have hand-held data entry devices programmed to disallow changes in data once entered. In any case, the particular system obtained by CTA enters clock times which cannot be modified.

MDTA and MARTA also have purchased hand-held data entry devices which feature alphanumeric keyboards and bar code reading capabilities. Both agencies are in the process of doing their own programming of the units, and will put them in use first in bus passenger data collection, followed by later application to rail rapid transit. Routines for both ride checks (on-board checks) and point checks (passenger load counts) are being programmed initially. For programming, MARTA purchased a complete software package, whereas MDTA purchased only a report generator. MDTA reports that having only the report generator language is limiting. Specialized PC software for analysis of data from the units is also being prepared, in-house in the case of MARTA, and under contract in the case of MDTA.

Alternative hand-held computer technology is now available for consideration in the form of devices that accept data via a pen-based operating system. Data are written in or checked off on a form that is displayed on the computer's writing surface. Such a device is currently being tested by NYCTA for gathering bus stop configuration data in the field.

Optical Character Readers

TTC use of an optical character reader for load count data entry is an alternative state-of-the-art approach to data entry that does not require use of hardware in the field, but instead retains use of paper and pencil field procedures. TTC's specially designed field sheets are fed into the optical character reader for scanning and editing. The data are then electronically transferred to a mainframe computer for further processing. Information on TTC's promising experience with this approach is covered in Chapter Three under "Passenger Load Counts."

IMPROVING DATA ANALYSIS

Enhancement of passenger data analysis capabilities is of as much interest to operators as data collection improvements. A considerable amount of data analysis is still done manually, and those analyses which are already computerized can always be made more useful and convenient.

Automated Traffic Clerking

NYCTA is moving into full scale automated data processing with its "Automatic Traffic Clerking" project. The specialized data processing system envisioned involves having a simple microcomputer-based local area network, providing data entry and analysis capabilities written in a common, user friendly language, with a structured query capability designed around traffic data analysis functions. Although hand-held computers or data entry devices are not part of the first phase project, plans to accommodate machine-readable data will be included. The design of data entry and summary forms will be similar to those currently in use.

There are more than 300 checkers operating at any one time on the NYCTA system, and the Automatic Traffic Clerking system will be designed to handle their output plus expected growth in the amount of data collection. Initially 10 users will access the system with 10 terminals, but the system will be designed for expansion to serve 30 to 40 users and workstations. The Automatic Traffic Clerking system will cover both rail and bus passenger data analysis, and will store and access up to three years of archived data.

Passenger Data Analysis Software

The NYCTA Automatic Traffic Clerking project is an example, on a large scale, of developing special purpose data analysis software under contract. This is one of three possible approaches to computerization of passenger data analysis, which are:

- Development of special purpose passenger data analysis software for the operator-specific applications desired, either in-house or under contract.
- Procurement of software designed for universal transit passenger data analysis application, already prepared by others, and appropriate for use in the rail rapid transit context.
- Use of standard personal computer spreadsheet, data base and statistical programs, aided as appropriate by templates and macros prepared for specific passenger data analysis functions.

In addition to NYCTA, both MDTA and MARTA are developing special purpose programs separate and distinct from automatic fare collection data processing. The MDTA and MARTA programs are, as indicated above, intended for processing data entered into a PC from hand-held data entry devices. Presumably the underlying program logic and report generators would function with data transcribed by any means.

Available software designed for universal passenger data analysis application has been used almost exclusively in connection with bus operations. Some software that has been designed to interface with hand-held data entry devices, is primarily oriented to bus on-board checks. Other software is intended primarily as an adjunct to on-board bus automatic passenger counters. SEPTA has purchased software for stand-alone use with manual data sources, and future use with hand-held data entry devices or automatic passenger counters. Currently, SEPTA is testing the software in both bus and rail on-board check and passenger load count applications, and making comparisons with the spreadsheet analyses regularly used. There is no federally sponsored passenger data analysis software.

A number of respondents to the synthesis survey report use of common PC software programs in passenger data analysis. Current software use is covered within each data collection category in Chapter Three, under the subheading "Data Entry and Analysis." All 10 operators responding to the synthesis survey make use of computer processing in at least some aspect of passenger data analysis. Six report use of a total of six different commercially available spreadsheet, data base, and statistical programs; four report using special purpose passenger data analysis software; another four have such software under development; and one is testing software designed for universal passenger data analysis, as described above.

RESEARCH PROBLEM NOMINATIONS

Table 16 lists the unmet data collection needs identified by the synthesis survey respondents in the context of their individual rail rapid transit operations. Also listed are any programs that the operator has underway to address unmet needs. The programs underway for which sufficient information is available have been summarized in the earlier sections of this chapter. Finally, Table 16 indicates those ridership data collection problems that the operators would like to nominate for cooperative research efforts.

Five operators identify unmet data needs involving origin-destination data. The unmet needs relate to incompleteness or lack of such data, or the difficulties of collecting it.

Four operators provide a total of five separate identifications of unmet needs that pertain to information that could be collected at point of station entry alone. These include hour-by-hour and day-of-week passenger data obtained continuously throughout the year, and differentiation among ridership and fare classes, such as among students, senior citizens, and free riders, or among transfers, passes, and tickets. These particular unmet needs are all listed by operators with less than state-of-the-art, entry-only fare collection equipment, and would all seem to relate to need for improved passenger data collection at the turnstile or equivalent. Indeed, three operators nominated turnstile improvements and automated data collection as research problems.

One unmet data need and one research problem nomination each pertain to sampling procedures, and a second pairing pertains to linked data for bus-to-rail transfer trips. A total of three research problem nominations address passenger data analysis software needs and/or Section 15 data analysis. Other identified data needs include information on frequency of pass use, performance indicators with a passenger orientation, and quick-response turnaround in passenger data analysis. Other research problem nominations include procedures for station area counts, universal standards for hand-held data collection devices, and automatic passenger counters. For a complete listing, refer to Table 16.

TABLE 16

UNMET RAIL RAPID TRANSIT DATA COLLECTION NEEDS AND RESEARCH NOMINATIONS SUGGESTED BY SYNTHESIS SURVEY RESPONDENTS

Operator	Reported Unmet Data Collection Needs	Solutions Underway	Research Problem Nominations
BART	Linked data for bus to rail transfer trips	Universal Ticket Program	Linked bus to rail transfer counts
	Origin-destination (O-D) and time-of-day information for discount tickets		
CTA	Station-specific data for fares collected on-board trains; on-board pass count		
	Turnstile counts at some stations (station layouts not conducive to turnstiles)		
	Reporting of reduced fare count by separate subgroups, for funding purposes		
	Complete count of free riders		
GCRTA	(See research problem nomination)		Means of using Section 15 Daily Trip Sheets to collect useful data on rail traffic
	Solutions to problems in counting passengers with transfers, passes and tickets		
	O-D, station-to-station, and hour-by-hour data		
MBTA	(See research problem nomination)		Info. on turnstile improvements, short of magnetic tickets, to increase fare collection flexibility
	O-D, rail-to-rail transfer data		
MDTA	Hour-by-hour and day of week data	Rail modernization grant being used to address this issue	Automated turnstiles downloading directly to computer
	(See research problem nominations)		Universal standards for hand-held data collection devices
			Analytical software for processing normal ridership reports, including Section 15
NYCTA	(See research problem nominations)	Automated Fare Collection project	Info. on automated fare collection; pro's, con's and how to implement
			More efficient techniques for sampling passenger flows
	Quick-response turn-around in summarizing traffic checks	Automatic Traffic Clerking project	
	Passenger orientation in management-oriented performance indicators	Passenger Oriented Performance Indicators	
	Continuous measurement, throughout the year, of peak vs. off-peak ridership		
	Sufficient information on ridership by the various ridership classes, e.g., students, etc.		
SEPTA	(See research problem nominations)		Software development
			Reasons for travel of non-regular riders
	Information on frequency of pass use	Automatic Fare Collection	
	Solutions to difficulties in obtaining O-D and transfer data		
TTC	More riding count data	Automatic Passenger Counters	Automatic passenger counters
WMATA	(See research problem nomination)		Procedures for station area counts
	Demographic profile of riders for marketing use		
	"True" O-D data for demand modeling		
	Valid sample size for the above		

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

Conclusions and recommendations are presented here in three parts, each with its own focus. First is an overview assessment of existing conditions in the collection and application of ridership data on rapid transit systems, and the implications of those conditions. Next, observations are offered with respect to the primary steps in ridership data collection, and how they might be improved. Finally, recommendations as to research needs are provided.

EXISTING CONDITIONS

A large amount of rail rapid transit ridership data is being collected for a broad array of uses. This data is being collected and used without benefit of any current industry norm, standards, handbooks, or manuals. Individual rail rapid transit operators do have established procedures, training programs, and instruction manuals, and most operators have taken innovative or improved approaches to at least some of their data collection needs. Techniques and approaches that are state of the practice for some operators offer potential for significant improvements for other operators. A number of operators have achieved significant accomplishments, even those with limited resources and uniquely demanding operating environments.

This is a particularly unfortunate moment in history to lack industry standards. There has been a perception that rail rapid transit is divided into two camps: systems with entry/exit fare control and associated automated fare collection equipment; and "older" systems, with mechanical turnstiles and a corresponding need to collect all data manually. In fact, the "older" systems are fast moving toward automated fare collection, complete with station and host computers, albeit without exit control. SEPTA has now installed automated fare collection in Philadelphia's subway stations, NYCTA currently is in the procurement process, and the CTA has initiated planning for automation. These automated fare collection systems will shape passenger data collection for decades to come. While each design reflects the perceived needs of the individual operator along with the vendor's technical advice, it cannot benefit from industry standards which do not exist.

Much of rail rapid transit passenger data collection and analysis remains labor intensive. Here again lack of industry norms and information exchange is unfortunate. Most operators report satisfaction with the data collected, but this satisfaction is often based more on "seat of the pants" assessment than any real statistical evaluation. Data collection activities which have been instituted under federal strictures, notably UMTA Section 15 requirements in the U.S., have been subject to some of the more careful survey designs. Many of the older "tried and true" techniques are undoubtedly valid, and should not be summarily rejected, but need examination to see if there are more cost effective and statistically valid approaches, or if enhancements could be obtained through even limited adjustments. A number of operators acknowledge that elements of their data collection and processing activities are due for overhaul, while other procedures are clearly state of the art. There is much to be learned from what individual operators have been able to accomplish with their own resources.

As noted in Chapter Four, the rail rapid transit industry has not moved heavily into hardware solutions for passenger data collection, aside from the movement toward automated fare collection. This should not be taken solely as an indication of resistance to change. Many hardware solutions have been conscientiously examined and found wanting in terms of cost, effectiveness, maintenance requirements, and reliability in the rail transit environment. The most productive area for new applications has been found at the interface between the human data collector and automated data processing.

The linkages between data collection, data processing, and data application are inherently the weakest links in obtaining and using passenger data to enhance system operation. In a number of cases these linkages appear to be poor. Some rail rapid transit operators have gone to the extent of sweeping departmental reorganization in order to foster these linkages and give appropriate emphasis to passenger data collection and use in concert. Ongoing vigilance is required to ensure that data collection is not treated as an end unto itself, but rather is keyed to the real information needs which exist in rail rapid transit performance analysis, operations planning, design, financial planning, and marketing.

SURVEY CONDUCT

Much of rail rapid transit passenger data collection and use is repetitive. In many instances, rightly or wrongly, the survey and analysis techniques used have been in place for many years. Other data collection needs are sufficiently distinctive as to dictate new approaches. New data collection deserves full allocation of resources to careful planning. Old techniques deserve review to take advantage of new ideas, improved understanding of statistics, and new technology.

Survey Design

The old saw, "Never enough time to do it right, but always enough time to do it over," offers a valid warning but does not particularly well describe survey conduct. Transit surveys present a more damaging scenario; conditions rarely allow doing surveys over. A survey done wrong simply results in bad data, often worse than none at all.

Most surveys are not undertaken on an emergency basis, and time is available to properly structure their conduct. Time spent in advance to think through and lay out all steps in the process, and how they interrelate, will avoid data problems that too often cannot be satisfactorily corrected. An example of inadequate survey design is failure to include a particular class or flow of passengers in a sample supposed to be representative of all riders.

A clear statement of the objectives of the data collection and analysis effort will provide a frame of reference for assessing the appropriateness of each element in the survey design. The principal steps of survey design include defining the population to be surveyed (e.g., all passengers entering the system), specifying the data to be collected, determining the degree of precision desired, selecting a method of measuring the desired data, developing a sampling plan, pretesting the survey, organizing the field work, and planning the data analysis (*10*). Selection of a method of measurement includes questionnaire design, if applicable, and several steps involve training and quality control. Special considerations involved in design of survey forms and survey factoring for self-administered origin-destination surveys were addressed in Chapter Three.

Passenger load counting is an example of a survey in use for many years that deserves review. For instance, most operators use a traffic checker for every two cars of train consist. TTC divides up the responsibility for counting and recording and obtains the same data with two-person crews. There are trade-offs between these techniques. TTC feels the need to assign traffic checkers believed to be particularly skilled, whereas other operators use their lowest paid traffic checkers. The idea deserves careful consideration, however, as does TTC's use of an optical character reader for data entry.

Sampling Design

Few of the many survey techniques in use for a long time appear to have been examined to see if they have an adequate statistical basis or could be streamlined through use of statistical sampling. There has been little analysis of variation in traffic among individual train runs on the same line, or among days of the week, or weeks of the year, of the sort that would give insight into what proportion of trains or what number of days needs to be covered. Most sample design work has been focused on origin-destination surveys, and on the data collection required by UMTA Section 15 regulations in the U.S.

Some rail rapid transit ridership data collection inherently involves counting every rider, particularly data regarding revenue collection. For many applications, however, sampling offers substantial advantages. Sampling, as compared to complete enumeration, has the advantage of reduced cost, quicker response, ability to expand the scope of a survey, and greater accuracy. Greater accuracy is achieved because with the smaller volume of work covered by a sample, higher quality survey personnel can be employed; they can be given more intensive training; and field work and analysis can be more closely supervised (*10*).

It is not enough, however, to select an overall sample size which is calculated by formula to provide the desired precision. In rail rapid transit ridership surveys, the more statistically satisfying methods of drawing a sample may be wholly impractical. For example, it is one thing to randomly select people out of a phone book and then call them, and an entirely different matter to select transit passengers truly at random and then try to track them down. In consequence, rail rapid transit samples tend to be selected on the basis of units like days, trains, or stations, introducing critical questions of dissimilarities in the traffic patterns between the units sampled (days, trains, or stations) and those not. Any count or survey sampling involving rail rapid transit passenger data must clearly be constructed carefully, with an eye to the practical considerations of fielding the survey and full consideration of what is actually being sampled.

Statistical precision calculations also beg the question of bias in self-administered surveys. The survey response rate in self-administered surveys is a function of the interest and ability of each person surveyed. In turn, the passenger's interest relates to such matters as his or her upbringing, education, and frequency of transit use. The passenger's ability relates again to education and also to language capabilities and whether a short or long time, seated or standing, is available to fill out the form. These relationships produce education, income, frequency of use, language, distance and location biases, including second order geographic biases related to differing distributions of housing and employment by income and ethnic group, and also second order time of day biases. A small sample that might be acceptable if biases could be ruled out or fully compensated for, can be totally unacceptable in the presence of important biases. Techniques for factoring out as much geographic and time of day bias as possible were discussed with respect to origin-destination surveys in Chapter Three.

Management and Training

The success of linkages between data collection, data processing, and data use is dependent on the priority management places on their effectiveness, and the support provided in terms of appropriate management structure. While management structures are beyond the purview of this synthesis, there are some basic guidelines that can be offered. It is useful to plot the path of data flow through an organization, identifying where accountability lies for collection, processing, and use. The more branches of an organization that data have to pass through, and the more fractured the accountability for performance, the greater the chance for poor results. If the collection, processing, and use of a particular data set cannot be consolidated in a single department, there is increased need for a well-articulated and enforced policy to ensure that the ultimate uses of the data, immediate and potential, are appropriately reflected in the design and execution of the data collection and processing.

Training of traffic checking staff ranges from well-structured to more informal procedures. NYCTA provides an example of a comprehensive training program designed to prepare relatively unskilled personnel for the requirements of passenger data collection. The TTC provides well-illustrated manuals for their surveys that open with a succinct statement of the use of the survey, recognizing that an effective employee is one who understands both the value of what he or she is doing and how to do it. Leaving conduct of data collection up to the best intentions of field personnel without proper guidance is at best an invitation for serious misunderstanding that can result in either patently erroneous or misleading data.

Data Entry and Analysis

Passenger data analysis is increasingly computerized, requiring some means of entering the data obtained by human observation. With two exceptions, the reported method was to record the data first on conventional field sheets or survey forms of one sort or another, and then manually key in this data as a separate activity.

One exception is TTC's use of an optical character reader to scan field entries electronically and enter the data into electronic media. As covered in Chapters Three and Five, TTC has found this approach to be successful in saving time and manpower without loss in accuracy, and is expanding the number of their standard surveys adapted to the process. Aside from having an optical character reader and associated software, the only requirement is that the field sheet be redesigned, mainly to ensure that each alphanumeric entry is lined up properly. No hardware is required in the field. This approach obviously deserves consideration by other operators.

The other exception is CTA's use, and the planned use by others, of hand-held data entry devices. This approach, in which the traffic checker keys in data directly, transfers the interface between the human observer and computer into the field. It eliminates altogether the step of translating handwritten data entries into electronic data. The tradeoff is the capital investment of purchasing the hand-held data entry devices and requisite computer programming, ongoing cost of equipment repair and replacement, and any premium paid traffic checkers using the devices. There is no rail rapid transit experience with repair and replacement costs. CTA does not presently entrust its lower paid traffic checkers with the data entry devices. Concerns about having an audit trail, such as is provided by use of conventional field sheets, can be accommodated by the manner in which the hand-held data entry devices are programmed, as explained in Chapter Five.

There would appear to be potential for cost savings if there could be some form of joint procurement of the computer programming required to set up the hand-held data entry devices for each individual survey task. Joint procurement would require standardization of each data collection activity involved.

Data Analysis

Although manual passenger data analysis is still extensively used, clearly its days are numbered. The three options for computer processing are use of standard spreadsheet and data base programs, purchase of computer software intended for transit operators in general, and development of special purpose programs designed uniquely for the particular requirements of the individual user. A number of operators seem to be making good use of standard programs. SEPTA provides an example of purchased computer software intended for transit operators in general, still in testing by SEPTA. CTA's programming of hand-held data entry devices and NYCTA's "Automatic Traffic Clerking" project are examples of uniquely designed software.

Use of standard spreadsheet and data base programs probably requires a somewhat higher degree of computer literacy than operation of software uniquely designed for the task at hand, at least in the case of user-friendly programs of the sort envisioned by NYCTA. Standard PC programs are likely to prove most cost effective for smaller operators and for the smaller and less frequent data analysis tasks of any size operator. Availability of program setups designed for rail rapid transit data analysis would be an obvious aid. The cost of uniquely designed programs may well be justified for large operations, particularly if making good use of office personnel is an objective. The viability of using computer software intended for transit operators in general will depend on the adaptability of the software available, and the degree of standardization that can be accepted and achieved.

RESEARCH NEEDS

The findings of this synthesis suggest several fruitful areas for research. In several instances the research could well cover all forms of public transit, as long as due attention is given to the special requirements and needs of rail rapid transit, remembering, again, that rail rapid transit accounts for more than a quarter of all public transit ridership.

Linkages with Data Uses

A more thorough understanding of the scope and details of passenger data needs, existing and potential, and of the linkages between data collection and data uses, would provide an improved basis for structuring data collection management, research, and development. The needed level of understanding cannot adequately come from synthesis type activities, but requires detailed, in-depth investigation of passenger data applications, as well as data flow from collection through processing and analysis to ultimate uses. A comprehensive and explicit exposition of data requirements and relationships would help define objectives and a frame of reference for subsequent passenger data collection and analysis research.

Standards and Manuals

The lack of any current industry norm, standards, handbooks or manuals covering rail rapid transit ridership data collection and use, and the limitations caused by that lack, were identified at the outset of this chapter. The development of such standards, and the concomitant preparation of handbooks or manuals, represent primary research needs.

In order to develop standards and manuals, comprehensive analysis is needed of sample selection and other statistical questions related to rail rapid transit data collection. Few of the professionals currently involved in the conduct or design of rail rapid transit counts and surveys have advanced statistical training, and guidance based on adequate research could remove a significant barrier to data collection improvement. Involvement in any such research of practitioners familiar with the constraints of the rail rapid transit environment would be essential. A unique test bed for examination of geographic and temporal biases in self-administered origin-destination surveys is offered by the BART Data Acquisition System, which can provide an independent measure of station-to-station origin-destination patterns for any time period desired.

In connection with overall development of standards, now is the time to prepare standards specifically covering the passenger and fare data collection, transmission, and reporting capabilities that should be provided for in automated fare collection equipment and systems. As already noted, older rail rapid transit systems have already begun the process of conversion to automated fare collection.

Software and Procedures

With use of standard spreadsheet and data base computer programs becoming common in the processing of rail rapid transit passenger data, availability of applicable program templates, macros, and suggested setups would be of assistance. This could be accomplished through applied research, software exchange, or both. Similarly, special purpose programs might be developed or distributed. The role of transit ridership analysis software developed in the private sector would need to be resolved.

There has been a perception that the type of traffic and performance simulations that BART uses to provide a continuous equivalent of the information otherwise provided by passenger load counts, on-board checks and other surveys is beyond the reach of systems without entry/exit fare control. The arrival of automated fare collection on older rail rapid transit systems would seem to render that premise obsolete. Systems with entry-only fare collection may well be able to pair periodically collected origin-destination and route choice information with real time entry-only automated fare collection data and schedule performance data to closely replicate the simulation capabilities achieved by BART. Research on this subject would need to address first, feasibility, and then, if appropriate, move on to development of software and detailed procedures.

Section 15 Requirements

When the process of rewriting Urban Mass Transportation Administration Section 15 requirements is complete, including approvals and required legislative action, it might be a propitious time to work with rail rapid transit operators to develop standards, manuals, software, and procedures to meet the requirements. If this is done, it is important that it be in context with passenger data needs of the operators themselves. Ironically, those operators who have conscientiously gone to the greatest lengths to accommodate current UMTA regulations and preferences (see "Station-to-Station Surveys" in Chapter Three) appear to be producing data of such narrow use that it has limited application to their own needs. Multipurpose data development, counting Section 15 reporting as only one of an array of useful applications, is needed for efficiency's sake.

Information Exchange

Telephone followup on the synthesis survey questionnaires has shown the state of the art in rail rapid transit data collection and use to have advanced significantly even during the course of this one synthesis project. However, there appears to be no functional mechanism to ensure that new developments by one operator are made known to others. Whether sponsored by government or industry groups, there needs to be exchange of information. At a minimum, research focused on development of standards and handbooks for rail rapid transit ridership data collection and use should include promotion of a means for updating what is developed and keeping information on the subject current.

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2. Buneman, Kelvin, *Automated and Passenger-Based Transit Performance Measures,* San Francisco Bay Area Rapid Transit District (December 1983) Figure 1.
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7. Multisystems, "Consumer-Based Transit Pricing at the Chicago Transit Authority, Final Report," prepared for Chicago Transit Authority, July 1991.
8. Teleride Corporation, "Systems and Methods for Determination of Rapid Transit Ridership Patterns, Project Report," prepared for the New York City Transit Authority. Teleride Corporation, Toronto, ON (1986). Report No. UMTA-NY-09-0083-86-1.
9. Mulqueeny, Jr., James, *Procurement and Deployment of Hand-Held Data Devices for Section 15 Data Collection,* prepared for the Metropolitan Conference on Public Transportation Research, University of Illinois, Chicago, June 7, 1991.
10. Cochran, William G., *Sampling Techniques,* John Wiley & Sons, New York, 1977.

APPENDIX A

REPORTS AND PAPERS FURNISHED BY RAIL RAPID TRANSIT OPERATORS WITH THEIR SYNTHESIS SURVEY RESPONSES

Bay Area Rapid Transit District:

"1987 BART Passenger Profile Survey," Office of Research, Department of Planning, Budget, and Research, San Francisco Bay Area Rapid Transit District, San Francisco, CA (1988).

"1989 Five Year Plan - Interim Update," San Francisco Bay Area Rapid Transit District, San Francisco, CA (1989).

"BART Patronage Reports, June, August, 1989," Office of Research, San Francisco Bay Area Rapid Transit District, San Francisco, CA (1989).

Buneman, Kelvin, "Automated and Passenger-Based Transit Performance Measures," San Francisco Bay Area Rapid Transit District, San Francisco, CA (1983).

Reinke, David, "BART Patronage Study," Office of Research, Department of Planning, Budget, and Research, San Francisco Bay Area Rapid Transit District, San Francisco, CA (1987).

Chicago Transit Authority:

"Fare Collection Method, Rail System Collection by Agents," OP-X87217, Chicago Transit Authority, Chicago, IL (1987).

"Rail System, Nov. 1988 Traffic," OPx89161, Chicago Transit Authority, Chicago, IL (1989).

"Market Analysis of CTA Fare Structure Options: Summary Report," four papers presented at the Metropolitan Conference on Public Transportation Research at the University of Chicago, June, 1988, Chicago, IL (1988).

"QuikPass User Surveys: Technical Report SP88-06," Strategic Planning Department, Chicago Transit Authority, Chicago, IL (1989).

Massachusetts Bay Transportation Authority:

"MBTA Ridership," Chapter 5 from unknown report, Boston, MA (1989).

Sullivan, Mary Ellen and Alicia Powell Wilson, "1985 MBTA Fare-Mix Sampling Program: Analysis and Documentation," CTPS Technical Report 57, Metropolitan Planning Organization, Boston, MA (1987).

Metropolitan Atlanta Rapid Transit Authority:

"1985 On-Board Survey Report Executive Summary," Metropolitan Atlanta Rapid Transit Authority, Division of Service Planning and Scheduling, Atlanta, GA (1987).

"1985 On-Board Survey Report," Metropolitan Atlanta Rapid Transit Authority, Division of Service Planning and Scheduling, Atlanta, GA (1987).

"Average Rail Trip Length," Metropolitan Atlanta Rapid Transit Authority, Division of Service Planning and Scheduling, Atlanta, GA (1989).

"MARTA Service Standards for Bus and Rail Operations," Metropolitan Atlanta Rapid Transit Authority Board of Directors, Atlanta, GA (1989).

New York City Transit Authority:

"An Analysis of Token Booth Queues - OP-X90174," Operations Planning, New York City Transit Authority, New York, NY (1990).

"Cordon Count 1989," a report by Operations Planning, New York City Transit Authority, New York, NY (1990).

"Operation Enforcement Program Reports Violation Recap: Cycle 1 - January, 1991," Operations Planning, New York City Transit Authority, New York, NY (1991).

"Operations Planning Department Background and History," a lecture given to the Summer Transit Career Academy, Class of 1990, Operations Planning Department, New York City Transit Authority, New York, NY (1990).

"Rapid/Surface Passenger Environment Survey - First Quarter 1990," 29th in a quarterly series on Rapid and Surface Passenger Environment Surveys published by the New York City Transit Authority, New York, NY (1990).

Toronto Transit Commission:

"Cash Fare Count Program," Operational Planning, Toronto Transit Commission, Toronto, Ontario, Canada (1982).

"Modal Split Count Program," Operational Planning, Toronto Transit Commission, Toronto, Ontario, Canada (1982).

"Origin-Destination Survey of Parking Lot Patrons at Subway Stations," Planning Department, Toronto Transit Commission, Toronto, Ontario, Canada (1981).

"Subway Station Usage Count Program," Operational Planning, Toronto Transit Commission, Toronto, Ontario, Canada (1982).

"Subway System Origin-Destination Survey," Toronto Transit Commission, Toronto, Ontario, Canada (1989).

"1988 Modal Split of Transit Patrons at Subway Terminals (including Islington and Warden Stations)," Operational Planning, Toronto Transit Commission, Toronto, Ontario, Canada (1989).

Washington Metropolitan Area Transit Authority:

"Assessment of Rush Period Rail Service Levels - Six Months Summary - January 1989 thru June 1989," Office of Planning, Washington Metropolitan Area Transit Authority, Washington, D.C. (1989).

"Automatic Fare Collection Requirements for the 89.5-Mile System," Office of Planning, Washington Metropolitan Area Transit Authority, Washington, D.C. (1988).

International Business Services, Inc. and Dynamic Concepts, Inc., "Final Report - 1987 Metrorail Passenger Survey for the Washington Metropolitan Area Transit Authority," Washington, D.C. (1987).

JHK & Associates, "Development-Related Ridership Survey Final Report," prepared for Washington Metropolitan Area Transit Authority, Washington, D.C. (1987).

Pickett, Robert A. and R. Wayne Thompson, "Formula For Allocation of the Washington Metropolitan Area Transit Authority's Metrorail Subsidy Requirement," Office of Planning and Development, Washington Metropolitan Area Transit Authority, Washington, D.C. (n.d.).

APPENDIX B
SURVEY SENT TO NORTH AMERICAN RAIL RAPID TRANSIT OPERATORS

Page A1

NCTRP 60-1 / Topic TS-15
SYNTHESIS OF CURRENT PRACTICE
Collection and Application of Ridership Data on Rapid Transit Systems

FORM A -- SYSTEMWIDE DATA COLLECTION AND APPLICATION PROCESS QUESTIONNAIRE
(Please use additional sheets as necessary and attach reports and descriptive material)

Transit Agency________________________________Date______________

1. Please indicate with checks in the appropriate boxes below what rapid transit data collection activities your agency has and what uses are made of them:

Uses of Ridership Data	Types of Rapid Transit System Ridership Data Collection Activities							
	1. Max. Load Point Counts	2. Boarding and Alighting Counts	3. Turnstile/ Fare Gate Tallies	4. Station Area Counts/ Surveys	5. Station-to-Station Counts/ Surveys	6. Origin-Destination Surveys	7. Rider, Trip and Fare Characteristics Surveys	8. Other (Specify)
Scheduling								
Operations Planning								
Systems Planning								
Design								
Financial Planning								
Cost/Subsidy Allocation								
Performance Analysis								
External Reports								
Marketing								
Other (Specify)								

2. Please identify the specific counts and surveys you take, by name, referencing them by number to the types of data collection activities listed across the top of the Question 1tabulation:

Ref.#	Name of Count or Survey	Annual Cost
______	______________________________	$ ______________
______	______________________________	______________
______	______________________________	______________
______	______________________________	______________
______	______________________________	______________
______	______________________________	______________
______	______________________________	______________
______	______________________________	______________
______	______________________________	______________
______	______________________________	______________
______	______________________________	______________
______	______________________________	______________
______	______________________________	______________
______	______________________________	______________

3. What is the annual cost you budget for each count or survey? (Enter above.)

Please arrange to have a "FORM B -- COUNT or SURVEY DESCRIPTION" (copies enclosed) filled out by the appropriate person for each count and survey listed above.

Please also arrange to have a "FORM C -- RIDERSHIP DATA APPLICATION DESCRIPTION" (copies enclosed) filled out by the appropriate user for each count or survey application you identified in Question 1.

4. How does your present and future fare system, including special fares and intermodal transfers, constrain or enhance your ridership data collection capabilities?______________

5. What Rapid Transit ridership data collection needs do you have that are not addressed by your current ridership data collection program?______________

If any of these needs or problems are not further described on one of the "COUNT OR SURVEY DESCRIPTION" forms, please provide additional information here, including:

a. Estimated costs to resolve the need or problem: Capital $________ Startup $________
Additional annual data collection costs $ ________

b. Benefits anticipated (such as improved scheduling and equipment allocation):__________

c. Additional data collection hardware or software that would be required:

Fare gate hardware? ________ Cameras? ________ Computers? ________________
Hand held data entry devices? ________________ Other? ________________
____

d. Recommended person to contact for more information about this need:

Name________________________ Organization____________________
________________________ Telephone No.________________________

6. What ridership data collection problems would you like to nominate for cooperative research efforts?____
____
____

7. Is there information you feel we should have about collection and application of ridership data on Rapid Transit Systems that has not been entered elsewhere on these questionnaire forms?
____
____
____

8. Who is the recommended person, yourself included, to contact for more information on your ridership data collection activities overall?

Name________________________________ Telephone No.____________________

Your assistance in this NCTRP Synthesis of Current Practice is sincerely appreciated. Please be sure that completed Forms B and C are included when you return this questionnaire.

NCTRP 60-1 / Topic TS-15
FORM B -- COUNT or SURVEY DESCRIPTION

(Please fill out one form for each count and survey taken, using additional sheets as necessary, and attaching reports and descriptive material)

Transit Agency____

Count or Survey____
(Per Form A, Question 2, "Name of Count or Survey")

1. What department is responsible for this count/survey?____________________

2. Does this particular Rapid Transit System ridership data collection activity involve:

   Manual counts? __ Fare gate data? __ Interviews? __ Self administered questionnaire? __
   Other data collection? (Please describe.) ______________________________

3. Please describe the design of this count/survey and/or furnish documentation (reports, instructions, manuals, etc.). ______________________________

4. When is this count/survey taken:

   Hours of day? __________ Days of week? __________ Months of Year? __________

5. What percent sample is counted or surveyed? __% of all (riders? __ trains? __ other? __)

6. If less than 100%, how is the sample selected for this count or survey? ____________________

7. How does the sample selection, and any biases inherent therein, relate to the accuracy, results, and intended use of the data? ______________________________

8. What count and survey forms are used by the surveyor or respondent, and in control of the survey? ______________________________(Please provide samples.)

9. What auxiliary data is obtained, such as actual train arrival and departure times vis-a-vis scheduled times? ______________________________

10. What number and type of personnel are utilized in the count/survey?

    __ Supervisors __ Technicians __ Temporary personnel
    __ Other (describe) ______________________________

11. What training and quality control measures are taken?____________________

12. If you have estimated the count or survey error, what is it?____________________

13. Is data entry accomplished:

Manually? __ Hand held data entry device? __ Computer data entry? __
Other? ____________________

14. Please describe any any data entry software involved, including error checking routines.

15. Please describe the standard analysis of this count/survey and/or furnish documentation (reports, instructions, manuals, etc.). ____________________

16. What hardware is used in this data collection activity?

Fare gate hardware? __________ Cameras? ________ Computers? __________
Hand held data entry devices? __________ Other:__________

17. Do you consider your current procedures and equipment to be state of the art? __________

18. What improvements to this data collection activity have you accomplished or are you studying?

19. What were or would be the costs? Capital $__________ Startup $__________
Additional annual data collection costs__ or savings__ $ __________

20. Who is the recommended person, yourself included, to contact for more information about this data collection?

Name____________________ Telephone No.____________________

21. Are there any other persons, including hardware or software suppliers, who are recommended as additional contacts?

Name____________________ Organization____________________
____________________ Telephone No.____________________

NCTRP 60-1 / Topic TS-15
FORM C -- RIDERSHIP DATA USE DESCRIPTION

(Please fill out one form for each principal use made of rapid transit ridership data, using additional sheets as necessary, and attaching reports and descriptive material)

Transit Agency____

Ridership Data Use Category____________________________
(Per Form A, Question 1, "Uses of Ridership Data")

1. What department is responsible for making this use of Rapid Transit System ridership data?____

2. Please describe this particular use and/or furnish documentation (reports, manuals, instructions, etc.):

   Purposes/Objectives? ____

   Procedures? ____

3. Which types of counts and surveys are used to obtain the ridership data involved?
   a. ____________________ b. ____________________
   c. ____________________ d. ____________________

4. How are the data defined for this application (for example, peak 15 minute peak direction load vs. total weekday volume in both directions, unlinked vs. linked passenger trips, etc.)? ____

5. Does the data provided meet the needs of this data application? ____________________

6. Are there any definitional or data compatibility concerns? ____________________

7. If ridership data for other modes in addition to Rapid Transit are used, what issues arise concerning comparability of data among modes, and how are they dealt with?
   ____

8. Is the data timely, or is quicker response needed? ____________________

10. Who is the recommended person, yourself included, to contact for more information on this data application?

   Name ____________________ Telephone No. ____________________

APPENDIX C

EXAMPLES OF RAIL RAPID TRANSIT PASSENGER COUNT/SURVEY FIELD AND SUMMARY SHEETS

The following examples of rail rapid transit passenger count/survey field sheets were included as figures in the text:

Figure 1 - Toronto Transit Commission Passenger Load Count Field Sheet Designed for Optical Scanning ("Subway/RT Count Field Sheet").

Figure 4 - Washington Metropolitan Area Transit Authority Self-Administered Origin-Destination Survey Questionnaire ("Metrorail Passenger Survey").

The following examples of rail rapid transit passenger count/survey field and summary sheets are provided here in Appendix C:

New York City Transit Authority passenger load count field sheet, "Rapid Transit Traffic Check".

New York City Transit Authority passenger load count passenger data transcription form, "Rail Traffic Survey Tally Card".

New York City Transit Authority passenger load count passenger data summary form (page covering a.m. peak period), "Stationary Load Point Check Summary" (page 2).

New York City Transit Authority passenger load count Running Time Summary form.

Metro-Dade Transit Agency on-board check field sheet, "Metrorail - Section 15".

Chicago Transit Authority Agent's Report.

Toronto Transit Commission station mode of access count form (one example out of 6 forms), "Number of Vehicles and Passengers Entering and Exiting Commuter Parking Lots".

Bay Area Rapid Transit District self-administered origin-destination survey questionnaire, "1987 BART Passenger Survey".

Toronto Transit Commission self-administered origin-destination survey questionnaire, "Subway Travel Survey".

Toronto Transit Commission fare mix survey field sheet, "Subway Fare Analysis".

New York City Transit Authority
Service Traffic Monitoring Unit

RAPID TRANSIT TRAFFIC CHECK

Name ________________________ Employee # ____________ Sheet ______ of ______

Day ____________ Date ____________ Start ______ : ______ am/pm Finish ______ : ______ am/pm

Route ________ Direction __________ Station ____________________ Station Code __________

Circle Car Position(s) 1 2 3 4 5 6 7 8 9 10 11

Route	Destination	Arrive Time	Actual Car Position(s) Assigned				Leave Time	Lead Car #
			Position # ______		Position # ______			
			Car #	Leave Load	Car #	Leave Load		

15-T-976 58-69 5M 5/88

NOTE: The form provides space for comments on any unusual occurrence(s) or incident(s) on the reverse.

New York City Transit Authority
Operations Planning Department

RAIL TRAFFIC SURVEY TALLY CARD

Page ____ of ____

Route ______________

Location (Station) ______________

Direction ______________

Prepared by ______________

Date of Check ______________

Day of Check ______________

Head Car #	Destination	Arrive Time	Leave Time					Passengers In Cars								Total Pass.	No. Of Cars	Comment
				1	2	3	4	5	6	7	8	9	10	11	12			

New York City Transit Authority
Operations Planning Department
Date Analysis Unit—Rapid

STATIONARY LOAD POINT CHECK SUMMARY

File # ______________

Page 2 of
Form 600

Route ______________ Prepared by ______________________

Location ______________________________ Direction/Terminal ______________________________

15-Min. Period Ending	Passenger Counts								Average of Checks			
	Date				**Date**				Overall Average			
	Total No. Pass.	No. of Cars	No. of Trains	Avg. Per Car	Total No. Pass.	No. of Cars	No. of Trains	Avg. Per Car	Total No. Pass.	No. of Cars	No. of Trains	Avg. Per Car
06:14:59												
06:29:59												
06:44:59												
06:59:59												
07:14:59												
07:29:59												
07:44:59												
07:59:59												
08:14:59												
08:29:59												
08:44:59												
08:59:59												
09:14:59												
09:29:59												
09:44:59												
09:59:59												
Subtotal												

9-T-831-2 58-69 1M REV. 4/88

New York City Transit Authority

Operations Planning Department

RUNNING TIME SUMMARY

page 1 of____
FORM 2000

File #____________

Route: ____________

Direction/Terminal: ____________

Weekday:___ Saturday:___ Sunday:___

Date of Check: ____________

Prepared By: ____________

Approved By: ____________

Date Started: ____________

Date Finished: ____________

Check Location																		Total Run Time	
Headcar #	Sched. Time	Actual Time	Actual Time	Dwell Time	Run Time	Actual Time	Dwell Time	Run Time	Actual Time	Dwell Time	Run Time	Actual Time	Dwell Time	Run Time	Actual Time	Dwell Time	Run Time	Total	Analysis

Metro-Dade Transit Agency On-Board Field Check Sheet

ROUTE: **METRORAIL** DIR: **NORTH** EFFECTIVE: 3-6-89

NAME__________ WEATHER__________ SHEET NO.____OF____

TRAIN NO.______ RUN______ NUMBER OF CARS______ CAR NO. 1 2 3 4 5 6

DATE______ DAY______ TIME START______ TIME END______

LOCATION	**TIME** --SCHED-- ARRV	LV	-ACTUAL-- ARRV	LV	**PASSENGERS** ARRV	OFF	ON	LV	
DADELAND SOUTH *					----	----			
DADELAND NORTH									
SOUTH MIAMI									
UNIVERSITY									
DOUGLAS ROAD									
COCONUT GROVE									
VIZCAYA									
BRICKELL									
GOVERNMENT CENTER *									
OVERTOWN/ARENA									
CULMER									
CIVIC CENTER									
SANTA CLARA									
ALLAPATTAH									
EARLINGTON HEIGHTS									
BROWNSVILLE									
MARTIN LUTHER KING									
NORTHSIDE									
TRI-RAIL									
HIALEAH									
OKEECHOBEE *							----	----	----

COMMENTS:

TOTAL OFF -> ____ ____ <- TOTAL ON

AGENT'S REPORT

Window Code Number	Type	Trick No.	Station/Line	Day	Date Trick Started
—					19

Visifare Console No.

	40 Token	40 Token + 15¢ W/T	Permit/Employee	Special Count	1.25 Full	1.50 Full W/T
End						
Start						
Diff						
	7)(RT)	8)(RTT)	(P/E)	(SC)	9)(F)	10)(FWT)

Traffic	
End	
Start	
Diff	

Defective Visifare/Register

Register No ____________

Time B O | Time B O | Time B O

Time Repaired | Time Repaired | Time Repaired

	90 Token	90 Token + 25¢ W/T	45 Reduced	60 Reduced W/T	Transfer Received	Monthly Pass
End						
Start						
Diff						
	11)(FT)	12)(FTT)	13)(R)	14)(RWT)	(TR)	(MP)

Public Aid Voucher	
Total Recvd.	
	30)(PAV)

25¢ Registered Transfer Sales	
FWT	
FTT	
Total FTS	

15¢ Registered Transfer Sales	
RTT	
RWT	
Total RTS	

	1.25 Full	.90 Token	.45 Reduced	.40 Token
Man. Reg. No				
End				
Start				
Difference				
	15)(MF)	16)(MFT)	17)(MR)	18)(MRT)

Summary of Transfer Sales	25 Full	.15 Reduced	20 Surcharge
1) Actual number assigned to trick			
2) Registered transfer sales	◄FTS	◄RTS	
3) Transfers issued free under unusual circumstances			
4) Unused transfers returned			
5) Add lines 2, 3 and 4			
6) Total number sold without registration - Subtract line 5 from line 1.			
	23)(D)	24)(E)	25)(SC)

Total Manual Registration Hand Tally			
1.25 Full	.90 Token	.45 Reduced	.40 Token
19)(FHT)	20)(FTHT)	21)(RHT)	22)(RTHT)

Line		Amount
7) (RT)	- .40►	
8) (RTT)	- .55►	
9) (F)	-1.25►	
10) (FWT)	-1.50►	
11) (FT)	- .90►	
12) (FTT)	-1.15►	
13) (R)	- .45►	
14) (RWT)	- .60►	
Manual Registers: 15) (MF)	-1.25►	
16) (MFT)	- .90►	
17) (MR)	- .45►	
18) (MRT)	- .40►	
Hand Tally: 19) (FHT)	-1.25►	
20) (FTHT)	- .90►	
21) (RHT)	- .45►	
22) (RTHT)	- .40►	
23) (D)	- .25►	
24) (E)	- .15►	
25) (SC)	- .20►	
26) Change left by passengers		
27) Total Revenue received Add lines 7 thru 26		
28) (TFT)	- .90►	
29) (TRT)	- .40►	
30) (PAV)	- .25►	
31) Refund Cards (total value)		
32) Total token, voucher and refund card value Add lines 28 thru 31		
33) Total calculated cash due with this report Subtract line 32 from line 27		

Partial Turn-Ins	Full Tokens	Reduced Tokens	Cash	Bag Number	Seal Number
No 6			0 0		
No 5			0 0		
No 4			0 0		
No 3			0 0		
No 2			0 0		
No 1			0 0		
Final Turn-In					
Total	28)(TFT)	29)(TRT)			

Agent Controller's Telephone
Ext. 411
IBT - (312) 664-8981
(312) 664-7193

Signature of Agent in Training		Window No	
Name	Badge No	Start hrs.	
		Finish hrs.	
Agent's Signature			
Name	Badge No	Start hrs.	
		Finish hrs.	

Tokens		Final Turn-In Cash	
Full	Reduced	Bills	
Receiver		Halves	
		Quarters	
		Nickels	
		Pennies	
		Dimes	
Stamp Here		Total	

Tokens		Cash
Full	Reduced	
Short	Auditor's Space	Over

Form 1377/Feb. 82 (17-0574-0)
Toronto Transit Commission

Number of Vehicles And Passengers Entering And Exiting Commuter Parking Lots

Station ______________________ Date ______________________ Page ____________

Parking Lot ______________________ Weather ______________________ Checker ____________

NOTE: (a) Number of vehicles in lot at start of count (0630) ______________________

(b) Number of vehicles in lot at finish of count (2400) ______________________

PERIOD ENDING AT	ENTERING VIA ______ Passengers Per Vehicle (include Driver)					EXITING VIA ______ Passengers Per Vehicle (include Driver)				
	1	2	3	4	5	1	2	3	4	5

1987 BART PASSENGER SURVEY

BART

Please help us understand your transit needs by answering a few questions about your trip on BART today.

STARTING POINT

1. Which BART station did you enter on this one-way trip?

______ (Entry station) (9-10)

2. How did you get to this BART station?

1 ☐ **Walked only. No. of blocks:** ______ (12-13)
2 ☐ **Taxi**
3 ☐ **Motorcycle/moped**
4 ☐ **Bicycle**
5 ☐ **Car:**
- 1 ☐ Drove alone
- 2 ☐ Drove or rode with ____ other persons and parked
- → **Did you park this vehicle:**
  - 1 ☐ In BART station parking lot (16)
  - 2 ☐ Elsewhere and walked ____ blocks
- 3 ☐ Dropped off by car

6 ☐ **Transit:**
- 1 ☐ Muni
- 2 ☐ AC Transit
- 3 ☐ County Connection
- 4 ☐ BART express bus
- 5 ☐ Employer or residence shuttle
- 6 ☐ Other: ____
- → **How did you pay that fare?**
  - 1 ☐ Cash only
  - 2 ☐ BART/bus transfer
  - 3 ☐ Muni Fast Pass
  - 4 ☐ AC/BART Plus Pass
  - 5 ☐ Other: ____

3. How did you decide what time to arrive at this station?

1 ☐ I knew the schedule for the train I wanted. (21)
2 ☐ I did not know the train schedule. I arrived when I could and waited for the next train.

4. Where did you come from? (Specify one)

1 ☐ Home
2 ☐ Work
3 ☐ School
4 ☐ Shopping
5 ☐ Medical, dental
6 ☐ Social, recreational
7 ☐ Personal business
8 ☐ Other. Specify: ______ (23)

5. Where is the location of this place that you came from?

______ (City)

______ (Street address or nearest intersection)

DESTINATION

6. Which BART station will you exit from at the end of this one-way trip?

______ (Exit station) (31-32)

7. How will you get from this BART station to your destination?

1 ☐ **Walk only. No. of blocks:** ______ (34-35)
2 ☐ **Taxi**
3 ☐ **Motorcycle/moped**
4 ☐ **Bicycle**
5 ☐ **Car:**
- 1 ☐ Drive alone
- 2 ☐ Drive or ride with ____ other persons from parked car
- → **Did you park this vehicle:**
  - 1 ☐ In BART station parking lot (38)
  - 2 ☐ Elsewhere and walked ____ blocks
- 3 ☐ Will be picked up by car

6 ☐ **Transit:**
- 1 ☐ Muni
- 2 ☐ AC Transit
- 3 ☐ County Connection
- 4 ☐ BART express bus
- 5 ☐ Employer or residence shuttle
- 6 ☐ Other: ____
- → **How will you pay that fare?**
  - 1 ☐ Cash only
  - 2 ☐ BART/bus transfer
  - 3 ☐ Muni Fast Pass
  - 4 ☐ AC/BART Plus Pass
  - 5 ☐ Other: ____

8. Where are you going? (Specify one) (43)

1 ☐ Home: → **What time did you leave home today?** ______ AM PM
2 ☐ Work
3 ☐ School
4 ☐ Shopping
5 ☐ Medical, dental
6 ☐ Social, recreational
7 ☐ Personal business
8 ☐ Other. Specify: ______ (49)

9. Where is the location of this place that you are going?

______ (City)

______ (Street address or nearest intersection)

OVER →

BART USE

10. Will your use of BART today be: (57)

1 ☐ Three or more one-way trips
2 ☐ Round trip (both directions)
3 ☐ Only one way: →

> **How will you (or did you) travel the other way?**
> 1 ☐ Bus
> 2 ☐ Ride from family/friends
> 3 ☐ Carpool
> 4 ☐ Other. Specify: ________
> 5 ☐ Did not/will not travel the other way today

11. What type of ticket did you use to enter the BART system? (59)

1 ☐ Regular BART ticket (blue): →

> **What was the value of this ticket when first purchased?**
> 1 ☐ $32.00 (high value discount)
> 2 ☐ Other. Specify: $ ________

2 ☐ Muni Fast pass
3 ☐ Elderly ticket (green)
4 ☐ Youth/handicapped ticket (red)
5 ☐ AC/BART Plus pass
6 ☐ Other: ________

12. Was a car, truck or van available to you for this trip? (65)

1 ☐ Yes 2 ☐ No

13. How often do you usually ride BART on weekdays? (Monday - Friday)

1 ☐ Every weekday (Monday - Friday)
2 ☐ 3 - 4 days a week
3 ☐ 1 - 2 days a week
4 ☐ Less than one day a week

14. How long have you been riding BART?

1 ☐ Less than 6 months
2 ☐ More than 6 months but less than one year
3 ☐ 1 - 2 years
4 ☐ 3 - 5 years
5 ☐ More than 5 years

15. Please complete the following:

During the last three months BART got me on-time to my destination ______% of the time.

VITAL STATISTICS

16. Sex: 1 ☐ Male 2 ☐ Female

17. Age: (72)

1 ☐ 12 or younger
2 ☐ 13 - 17
3 ☐ 18 - 24
4 ☐ 25 - 34
5 ☐ 35 - 44
6 ☐ 45 - 64
7 ☐ 65 and over

18. Are you:

1 ☐ Employed full-time (in Bay Area): →

> **How many other related persons in your household are employed full-time?**
> ________
> Number of persons

2 ☐ Student (Full-time)
3 ☐ Visitor/Tourist
4 ☐ Homemaker
5 ☐ Retired
6 ☐ Other: ________

19. How many cars, trucks, or vans are there in working condition in your household? (75)

1 ☐ None
2 ☐ One
3 ☐ Two
4 ☐ Three or more

20. How many other related persons are living in your household?

____
Number of persons

21. What is the total income of all related persons living in your household, including yourself?

1 ☐ $15,000 or under
2 ☐ $15,001 - $25,000
3 ☐ $25,001 - $35,000
4 ☐ $35,001 - $50,000
5 ☐ Over $50,000

COMMENTS

22. Please give us your comments about BART.

____
____
____
____
____

THANK YOU FOR YOUR HELP. PLEASE RETURN THIS QUESTIONNAIRE TO THE SURVEYOR ON THE TRAIN.

OVER →

Figure 2

SUBWAY TRAVEL SURVEY

IF YOU ARE MAKING ANOTHER SUBWAY TRIP TODAY, YOU WILL BE GIVEN ANOTHER CARD AT THAT TIME.

please deposit this card
in the containers provided

AS YOU LEAVE THE SUBWAY

thank you

(PLEASE TURN OVER)

IF YOU DO NOT CHANGE TRAINS AT EITHER OF THE STATIONS IDENTIFIED ON THE RIGHT, SIMPLY DEPOSIT THIS CARD AS YOU LEAVE THE SUBWAY

ON THIS TRIP

if you change trains at
BLOOR YONGE STATION
please remove this corner

if you change trains at
ST. GEORGE STATION
please remove this corner

CDC 6436R

(PLEASE TURN OVER)

Form 874 / Feb. 82 (TP-400A)
Toronto Transit Commission

Subway Fare Analysis

SUBWAY STATION ________ PASSIMETER NUMBER P- ________ DATE ________

TIME PERIOD (ONE HOUR INTERVAL) FROM ______ TO ______ CHECKER ________ SHEET ________

METRO PASS (a)	CASH FARE PAYMENT FOR RIDERS INVOLVING COINS										SUNDAY OR HOLIDAY PASS (b) (show No. of persons per pass in appropriate column)					
	ADULT			SCHOLAR				CHILD								
	EXACT CASH (75¢)	CHANGE MADE (75¢)	CLOSEST CASH (80¢)	EXACT CASH (40¢)	CHANGE MADE (40¢)	CLOSEST CASH (45¢)	CLOSEST CASH (50¢)	EXACT CASH (25¢)	CHANGE MADE (25¢)	CLOSEST CASH (30¢)	1	2	3	4	5	6-

CASH FARE PAYMENT FOR RIDERS INVOLVING BILLS

AMOUNT		DESCRIPTION OF GROUP				NUMBER OF OCCURRENCES
$1.00	for	1	Adult			________
$1.50	for	2	Adults			________
$1.15	for	1	Adult	1 Scholar		________
$1.00	for	1	Adult		1 Child	________
$1.25	for	1	Adult		2 Children	________
$ ______	for	—	Adult(s)	— Scholar(s)	— Child(ren)	________
$ ______	for	—	Adult(s)	— Scholar(s)	— Child(ren)	________
$ ______	for	—	Adult(s)	— Scholar(s)	— Child(ren)	________
$ ______	for	—	Adult(s)	— Scholar(s)	— Child(ren)	________

NOTE: (a) Metropass consists of two parts: a permanent photo identification and a monthly pass portion
(b) Permits unlimited travel in Metro for a group of one to five persons (maximum 2 adults)