NATIONAL COOPERATIVE TRANSIT RESEARCH & DEVELOPMENT PROGRAM

6 Synthesis of Transit Practice

Transit Bus Fare Collection: Problems with and Alternatives to Paper Currency

TRANSPORTATION RESEARCH BOARD
National Research Council

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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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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 useful to administrators, finance officers, and others concerned with the problems associated with collection of dollar bills on buses. Information is presented on the nature of the problems and on potential solutions.

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.

As transit fares approach $1.00, the quantity of dollar bills received in fare boxes skyrockets. This causes problems within the fare boxes as well as with the handling of the bills after they are removed from the buses. This report of the Transportation Research Board explains the problems, describes the equipment being used to minimize

the problems, and gives alternatives (tokens, tickets, passes, prohibition of dollar bills, postpayment, etc.) that are designed to reduce or eliminate collection of dollar bills.

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.

TRANSIT BUS FARE COLLECTION: PROBLEMS WITH AND ALTERNATIVES TO PAPER CURRENCY

SUMMARY

Experiences of bus transit agencies in the United States indicate that an increase in fare to 80 cents triggers a significant influx in paper currency. The increase in paper currency poses significant problems in all areas of transit fare collection. Until recently, fareboxes were not designed specifically to accept paper currency. Use of paper currency in these boxes frequently leads to jams requiring a roadcall, or results in lower farebox capacity requiring more frequent vault removal, and encourages passenger fare evasion. Because fareboxes generally process bills more slowly than coins, dwell times can increase significantly on routes with high passenger volumes. Although coins can be handled quickly and reliably by machines, processing paper currency is largely a labor-intensive and expensive operation that provides many opportunities for the security of the revenue to be compromised.

Transit industry solutions to the paper currency problem have focused on streamlining revenue-handling capability or reducing the amount of currency collected. These solutions include:

- Acquisition of electronic fareboxes
- Installation of automated currency-processing equipment
- Use of contract services
- Bans on paper currency
- Subsidized low fares
- Fare prepayment
- Postpayment

A clear-cut solution to the paper currency problem has not yet evolved. Transit agency experiences with these solutions have been mixed. Each alternative presents a number of trade-offs that must be evaluated in light of specific system characteristics, such as system structure, passenger volumes, and the local political climate. For most transit agencies, the immediate choices are to use existing fareboxes and encourage fare prepayment or to acquire the latest generation of electronic fareboxes. Industry momentum appears to be building in the direction of the electronic farebox as the long-term solution. The adequacy of this equipment is only now being tested through its widespread implementation.

CHAPTER ONE

INTRODUCTION

PAPER CURRENCY IN TRANSIT FARE COLLECTION

For the greater part of this century, paper currency presented few problems in transit fare collection. Few patrons used paper currency to pay their fares as long as fares remained relatively low. Those who did were easily accommodated because drivers, before the mid 1960s, were responsible for making change, recording farebox readings, and turning in the corresponding revenue to the (then largely private) transit company. At that time, rising fares and increasing use of paper currency had little impact on the procedural aspects of fare collection because all fares were recycled and retained by the driver (or conductor).

In the mid-to-late 1960s, fare-collection procedures began to change radically—both in North America and in Europe. North American transit agencies moved rapidly to an exact-fare policy because of the increasing incidence of robberies and assaults. As a result, North American agencies adopted the cash-into-the-farebox philosophy and the accompanying secure farebox that typify today's operations. Fortunately, fares were low enough at the time to make exact fares palatable to the public. It was also fortunate that at the same time the industry was undergoing a transition from the private to the public sector and the prevailing attitude was to encourage both low fares and flat fares. For nearly two decades, North America presented an ideal setting for the simple dropbox for a coin/token-based fare.

Europe's fare-collection evolution, on the other hand, was vastly different. Facing labor shortages and the need to eliminate the conductor from its predominantly two-person operations, the European transit system sought to transfer greater responsibility to the driver but encountered stiff resistance from the drivers. As a result, most European agencies adopted a general philosophy of trying to minimize cash payment on the vehicle. A variety of alternatives were provided and a range of incentives (and disincentives) were offered to encourage their use. Unlike its North American counterpart, the European transit agency has experienced few paper currency problems on board the vehicle.

PROBLEMS OF PAPER CURRENCY

Paper currency poses a number of problems in all areas of transit fare collection. The most publicized problems have been those associated with the handling of dollar bills by simple, nonregistering, drop-type fareboxes. Such fareboxes were not designed to accept paper currency and the use of paper currency in these fareboxes frequently leads to jams requiring a roadcall, or results in lower farebox capacity requiring more frequent vault removal, or encourages passenger fraud because the driver cannot visually inspect the currency deposited. These problems alone have forced some transit agencies to attempt to ban the dollar bill for the payment of fares and have encouraged an even greater number to procure more compatible fareboxes.

Paper currency also presents a host of less publicized but still significant problems—both for those who merely accept the increasing influx and for those who attempt to implement "solutions" to the problems. On routes with high passenger volumes, dwell times can increase significantly because fareboxes generally process bills more slowly than coins. The cost of handling bills between the farebox and the bank can be substantial. Even a successful campaign of banning the bill (or implementing new fareboxes) can lead to increased costs in some areas, e.g., in maintenance and continuing public education. Similarly, a move to alternative fare-collection procedures, such as the Europeans took, has its own set of problems as the Europeans are now finding out. The removal of paper currency from the vehicle frequently transfers the problems to a new location and must be the subject of new solutions.

PURPOSE OF SYNTHESIS

This synthesis examines the problems with and alternatives to paper currency in bus transit fare collection. The magnitude of the overall problem is assessed and the numerous contributory problems of dealing with, or reducing or eliminating paper currency in bus transit fare collection systems are identified in Chapter 2. It reviews the numerous options for dealing with paper currency and the associated trade-offs for mitigating the more significant problems and, where practical, documents their success. Chapter 3 discusses approaches for improved revenue handling. Alternative methods for eliminating paper currency are described in Chapter 4. Chapter 5 presents conclusions based on a comparison of the major options for dealing with dollar bills.

CHAPTER TWO

THE PRESENT PERSPECTIVE

Paper currency has become a serious, contemporary problem in bus transit fare collection. As fares rise, more and more transit agencies are experiencing a substantial influx of paper currency and, with it, a whole range of problems. Responses have varied as have attempts at solutions. Some transit agencies have gone so far as to attempt to ban the use of paper currency for the payment of fares on the vehicle. A greater number are opting for a new generation of fareboxes that accept, register, and segregate paper currency. Still others are considering alternative fares and/or new fare-collection techniques, such as greater use of period passes in combination with pass readers.

Quite a few are uncertain as to how to proceed because none of the so-called solutions offers a true panacea for the problem. Many U.S. transit agencies appear to harbor the hope that the U.S. Treasury will recognize the paper currency problems and will solve them with a resurrected (modified) Susan B. Anthony dollar coin. Canadian and European agencies are pressing for similar solutions even though it is recognized that ultimately paper currency problems will reemerge as inflation moves fares to the next denomination of paper currency.

MAGNITUDE OF THE PROBLEM

Dramatic increases in the use of paper currency for the payment of fares began to take place a few years ago—hitting larger transit agencies quite severely. Experiences throughout the industry are similar. As fares approached the dollar level in both the United States and Canada, use of paper currency rapidly increased. In fact, it is not necessary to have a dollar fare for this to occur. Evidence suggests that an 80-cent fare level can trigger a significant increase in paper currency use.

The Chicago Transit Authority (CTA), for example, was collecting approximately 30,000 dollar bills on an average weekday in early 1981 when the CTA fare was 60 cents. Following a fare increase to 80 cents, the CTA dollar-bill volume increased to 80,000 per day. When fares increased to 90 cents in July 1981, the volume of dollar bills jumped to almost 300,000 per day (*1*).

The Southern California Rapid Transit District (SCRTD) experienced similar circumstances during the same period. SCRTD was receiving fewer than 8,000 dollar bills per day in early 1981 when the base fare was 50 cents. Following a fare increase to an 85-cent base fare in July 1981, SCRTD's dollar-bill volume jumped to 90,000 per day by October and was 103,000 by December—despite an official policy of discouraging dollar bills (*2*).

In June of 1982, when the base fare was 75 cents, the Washington Metropolitan Area Transit Authority (WMATA) was collecting between 45 and 50 thousand dollar bills on an average weekday (*3*). WMATA's current 80-cent base fare generates 65,000 bills per day. Seattle Metro used to get $30,000 in paper currency daily but in October 1984 was receiving $120,000. Seattle expected this figure to double in February 1985 when the cost of a two-zone peak fare was to increase from 90 cents to $1.00 (*4*).

Most of the publicity surrounding increased use of paper currency has come from the larger transit agencies. This is partly because the absolute magnitudes of the increases tend to be more newsworthy than the proportionate increases that may be occurring at small and medium agencies. Larger agencies also tend to have significantly higher passenger volumes on most blocks of work and frequently have either higher base fares or more supplemental charges (for transfers, zones, etc.) than the industry average. For example, SCRTD's problems were compounded by the fact that when the base fare advanced to $0.85, its $0.15 transfer charge made the fare exactly $1.00 for many passengers (*3*). Small and medium agencies are, however, experiencing an increase in use of paper currency. Citing the influx of dollar bills, the transit agencies in Sacramento, California; Vancouver, Washington; and Worcester, Massachusetts contracted for bill-accepting fareboxes in 1983 (*5, 6*) and the agency in Springfield, Massachusetts returned to the use of tokens (*7*).

Based on the trends of the past few years, any transit agency whose fares approach the value of a denomination of paper currency can expect to see that denomination of paper currency in significantly greater quantities. The U.S. transit industry as a whole is seeing substantial quantities of dollar bills. Transit agencies in England have been experiencing an influx of one-pound notes and a few in Canada are beginning to see increased use of the two-dollar bill.

Paper currency is likely to continue as a problem for the foreseeable future. For the past several years, rumors of a U.S. solution via the U.S. Treasury in the form of a resurrected Susan B. Anthony (SBA) coin have surfaced repeatedly. In fact, more than two years ago it was reported that the U.S. Mint and the Federal Reserve System would reissue the SBA as a bronze alloy coin that would overcome the public's objections to the current SBA. However, such action has not taken place and there is a very real prospect that by the time such action does take place that the one-dollar-bill problem will be replaced by a two-dollar-bill problem—especially since part of the plans for a resurrected SBA reportedly include a major campaign to encourage use of the two-dollar bill. Waiting for a Treasury solution is not a viable option.

THE PROBLEMS WITH PAPER CURRENCY

Paper is a difficult medium to handle and its problems are not confined to either the transit industry or paper currency. Paper jams are the most common cause of photocopier downtime and check handling is a major expense in the banking industry. Paper currency in the traditional drop-type farebox can truly be an anathema. This type of farebox was designed for low cash fares requiring a small number of coins. Typically, passengers must fold paper currency several times in order to deposit it into this type of farebox. Some passengers, recognizing that the driver cannot verify the fare because of the folded bill, cheat by tearing their bills in halves or quarters.

Once in the farebox, dollar bills frequently cause jams that may force the vehicle to be removed from service or result in increased maintenance. Then, because bills must be folded to enter the farebox, they must be unfolded to be counted. The manual processing involved in unfolding, flattening, stacking, and counting the currency is labor intensive and expensive. This process also provides many opportunities for the security of the revenue to be compromised.

Farebox Reliability

Most of the transit agencies that have had a large influx of paper currency have also experienced a number of farebox problems. The severity of these problems depends on the type of farebox, the relative proportion of paper currency versus coins, and the extent to which the paper currency is folded. The very simplest of drop-type fareboxes can accommodate a reasonable percentage of dollar bills provided the bills are folded several times so that they drop readily into the vault and provided coin volume is sufficient to "pack down" the bills in the vault.

In general, dollar bills require improved farebox security. However, more secure fareboxes with their serpentine, "anti-fish" money paths and multiple stanchion and vault shutter plates offer significant opportunities for paper currency jams. Without significant coin volumes to draw the currency into the vault, fareboxes rapidly become overstuffed to the point that the vault cannot be removed because the currency prevents the interlocking shutters from closing properly. In addition to the fact that this condition likely removes the bus from service and requires a replacement bus to be placed into service, the transit agency must bear the labor costs of clearing the jam plus repair the damage that frequently occurs to the farebox, the vault, and the currency itself.

Such problems can be particularly severe. For example, the CTA in September 1981 was experiencing 6,000 jammed and broken farebox canisters each week and had to ship back a significant number of these to the manufacturer at a repair cost of $171.00 per canister (*8*). To avoid these types of problems, many agencies were forced to empty the farebox more than once a day. On some of the longest runs in Virginia, WMATA reported removing money from its fareboxes as often as three times a day (*3*).

Currency Processing Costs

The most significant cost associated with currency handling is the processing cost following its removal from the farebox. Whereas coins can be handled quickly and reliably by machines, paper currency is largely processed by hand. When the CTA was receiving approximately 300,000 dollar bills in July 1981, 80 persons were required to process the paper currency (*8*). Similarly, SCRTD had to increase the number of persons handling currency at the central counting facility from 18 to 56 persons following its fare increase from 50 cents to 85 cents (and 103,000 bills) (*3*). A 1982 study by Custom Engineering for the Transportation Systems Center estimated the cost of sorting, stacking, and counting dollar bills to be "at least between two cents and ten cents" (*9*). More recently, in March 1984 Calgary estimated the cost of handling dollar bills at eight cents each (*10*). The magnitude of these costs can be significant. In 1982, Chicago's costs were $0.5 million per year and Washington D.C.'s were $0.25 million per year (*11*).

Revenue Integrity and Security

Revenue losses are a greater concern with paper currency than with coins. First, the passenger is presented with the opportunity to shortchange the farebox by an even greater amount than was likely with coin-only fares by depositing only a half or a quarter of a dollar bill. WMATA, for example, was receiving approximately a thousand half-bills out of its total daily intake of 50,000 dollar bills (*3*). Then, there are the opportunities provided to the driver. Paper currency frequently can make it all too easy for the enterprising driver to intercept the fare before it reaches the farebox in even the most sophisticated systems.

However, the more severe problems are likely to be encountered after the revenue has reached the farebox. A large volume of dollar bills can undermine the security and integrity of the revenue extraction, counting, and processing functions in a variety of ways. Paper currency can frequently prevent vaults from sealing properly on removal and may expose the currency to a number of individuals before it is secured at the collection point. Gravity-based vault-dumping procedures also do not guarantee that all bills will be removed from the vault, leaving a significant number of bills in the bus's vault when the bus is stored at night and presenting an obvious opportunity for subsequent removal by transit personnel. During processing, paper currency requires special precautions to ensure its security because it can be more readily concealed and because it must be physically handled by more individuals through more operations than coins or tokens.

RECENT POLICIES AND STRATEGIES

Since the advent of the paper currency problem, the transit industry has responded to the problems in various ways and with varying degrees of success. These solutions have been directed at either improving revenue handling in general or reducing the amount of currency collected.

Transit agencies that have focused their efforts toward improving revenue handling have acquired electronic fareboxes with enhanced bill-handling capability and/or automated currency-processing equipment similar to that used in banking. A few have contracted out revenue handling to private companies such as armored car services or banking institutions.

A variety of approaches to reduce or eliminate currency have

been tried. A few transit agencies have vigorously pursued campaigns to ban paper currency from their systems. Others have sought to maintain fares at low enough levels to ensure that coins remained the dominant form of the collected fares. Still others have sought "solutions" based on "new" methods of fare payment such as tickets, tokens, and passes.

CHAPTER THREE

IMPROVED REVENUE HANDLING

With the dramatic increase in the time and cost of unfolding, flattening, and counting paper currency with drop-type fareboxes and manual processing procedures, many transit agencies focused their solution to solving the paper currency problem by adopting equipment that would handle and process the growing influx more efficiently. This was made possible by changes in the supply industry associated with fare collection and revenue-processing equipment. Farebox manufacturers introduced electronic, registering fareboxes that provided a partial solution to the problems of folded bills. In addition, suppliers of currency-processing equipment that serve the banking industry have entered the transit market with new products for automated bill processing.

Although automated equipment is a potential solution to some currency-handling problems, in general, current equipment designs are not well suited for the transit environment. To date, reaction from the transit industry has been mixed. (See Appendix A for a list of fare collection and revenue-processing equipment manufacturers.) Other transit agencies took a completely different tactic—they turned over their revenue handling to private contractors such as armored car services or banking institutions. These alternatives are described below along with their advantages and disadvantages.

ELECTRONIC FAREBOXES

The transition to electronic fareboxes began in the early and mid 1970s. The early electronic, registering fareboxes were not introduced in response to the problems of paper currency nor were they intended to provide such a solution. In many respects, these early products were the electronic equivalents of their predecessors. They reflected a general conversion from mechanical to electronic components in much the same manner as adding machines were being replaced by electronic calculators.

History of Electronic Fareboxes

The focus of the original electronic fareboxes was only tangential to the problems of dealing with paper currency. They provided a separate slot so that the passenger could deposit a dollar bill without folding it and provided a separate viewing area so that the driver could inspect the bill in its unfolded state and verify its validity. These features were highly desirable from the standpoint of preventing fraud during fare payment but they were only marginally effective in dealing with greater numbers of dollar bills. Paper currency continued to be commingled with coins leading to jams and a continuation of high revenue-processing costs.

These early fareboxes were primarily designed to deal with the then current (and continuing) problem of farebox short-changing. The bill-accepting and bill-viewing features were a part of this overall design philosophy. The major emphasis, however, continued to be coins. More and more transit agencies were experiencing, or suspecting, a growing incidence of short-changing. As fares rose, it became more difficult for the driver to verify the amount of the coins dropped into the farebox and passengers began to realize that it was relatively easy to deposit less than the full amount. Farebox manufacturers responded by providing a farebox that counted the coins and displayed the deposited amount.

In the ensuing years, the "new" generations of fareboxes represented refinements of the original design and attempts to resolve some of the problems that developed with the designs. There was still no concerted effort to design specifically for dollar bills as the market for such designs was highly uncertain. Dollar bills began to cause some difficulties; e.g., bills frequently would not fall from the vault during the standard dumping procedure. Such problems were dealt with by reacting to each problem on a case-by-case basis. For example, in the case where the bills remained in the vault, the "solution" at one transit system was an air jet installed in the dumping mechanism to flush out the remaining bills; other systems took to such elementary procedures as rapping the vault several times with a mallet during the dumping process.

The major movement in electronic fareboxes in the late 1970s was not to improve bill handling but to incorporate data-collection features. New fareboxes being promoted were demonstrating a variety of data-collection features designed to facilitate the reporting of Section 15 data and to establish a revenue audit trail.

Serious, direct design for the handling of paper currency is a relatively new goal of the farebox manufacturer. These products are just now entering revenue service in significant volumes. Recent application of this equipment at the largest transit agencies will permit an assessment of its performance in high-volume revenue operation. CTA recently contracted for the purchase of 2,500 bill-accepting fareboxes. SCRTD conducted a 45-day test of 900 units (with 700-bill capacity) in its downtown area

in early 1985 as part of a feasibility study for retrofitting its entire fleet.

Advantages and Disadvantages of Electronic Fareboxes

With a drop-type farebox and manual processing of paper currency, the breakdown of the time involved in processing the currency is approximately 65 percent for unfolding, 15 percent for flattening, and 20 percent for counting, once the bills have been separated from the coins (*12*). Clearly, the most significant savings are derived from an approach that reduces the effort involved in the unfolding of dollar bills. This is met to some degree by all electronic, bill-accepting fareboxes. Bills must be presented to the farebox in unfolded form compared to the multiple folds required by most drop-type fareboxes.

In May 1982, an article addressing the dollar-bill problem in *Mass Transit* stated: "The most plausible technological answer is electronic, or registering fareboxes" (*11*). Indeed, a number of transit systems, small and large, have agreed and have moved to these newer, more sophisticated fareboxes. However, the cost implications of these decisions are not insignificant. The price tag of the electronic registering fareboxes ranges from $2,500 to $3,000 each depending on the features selected. Historically, the reliability of the electronic fareboxes has been a problem at many transit agencies. The more sophisticated equipment appears to be sensitive to environmental factors and some components have a relatively short life. Maintenance requirements for electronic fareboxes are considerably higher than for traditional drop-type fareboxes. (See References *9* and *13* for a thorough discussion of electronic farebox reliability and maintenance experience.)

In addition, it is important to classify electronic fareboxes carefully. Most of the existing electronic fareboxes in revenue operations today were designed for purposes other than handling dollar bills. In choosing a new farebox, the transit system must be careful to select those features that match its particular needs. Labels such as "electronic," or "registering," or "bill-accepting" may not fully characterize the intended system if the primary intent is to reduce overall currency-handling problems.

Single-Compartment Fareboxes

The single-vault version of the electronic farebox is adequate for modest amounts of paper currency and performs best when coins are present in sufficient proportions to ensure that the bills are drawn into the vault. Where a single vault is used for both coins and paper currency, the commingling and subsequent dumping operations will disorganize the currency to the extent that considerable unfolding may still be required. Such a system will, nonetheless, produce modest savings in some processing costs. It should virtually eliminate the collection of partial bills and thereby eliminate the associated costs of matching, taping, and processing these bills. (Some large agencies such as WMATA have been able to avoid the costs of matching dollar bills by negotiating directly with a Federal Reserve Bank for the reimbursement of half bills. However, the general banking industry continues to require bill matching of most customers.) It will remove a variety of frustrating circumstances that push up the cost of bill processing dramatically—such as the well-meaning passenger who deposits a $1.25 fare in a neat, little package in which the coins are wrapped in the dollar bill and the bill is securely taped.

Dual-Compartment Fareboxes

For most applications, a dual-compartment vault is the preferred approach to handling moderate amounts of dollar bills. Paper currency remains separate from coins and retains its unfolded state to a greater degree in even the less sophisticated dual-compartment fareboxes; i.e., ones that do not stack the dollar bills. For high-volume situations, a bill-stacking farebox vault coupled with an automated vault that keeps bills open, flat, and ready for counting may be necessary to reduce processing costs to manageable levels.

Add-on Devices

During 1982 and 1983, serious thought was being given to the use of add-on devices that could be used in conjunction with the existing drop-type fareboxes to handle dollar bills. In 1982, the CTA completed a study of several such devices (*8*). Several manufacturers of bill validators began to develop and test prototypes of such add-on devices (*14*). Such approaches did not advance beyond the prototype stage because of the perceived difficulties of having to vault to different pieces of equipment and of dealing with two separate suppliers of fare-collection equipment.

CURRENCY-PROCESSING EQUIPMENT AND PROCEDURES

Following the transfer of the contents of the farebox vault to a collection vault, revenue processing begins. Except for the sorting and counting of coins, this revenue processing is almost exclusively a manual operation in most transit systems. Experiences with automated systems have been decidedly mixed.

Money Separators

In single-vault farebox systems, the first step in revenue processing is the separation of coins and tokens from paper currency and tickets. Automated money separators have been on the market for a few years and operate on the principles of blowing or vacuuming off the paper currency or vibrating the coins through the paper currency and through a receiving sieve.

Typical of these systems is the separator used by the Regional Transportation District (RTD) in Denver. The contents of the farebox vault fall onto a moving conveyor belt during the normal dumping process. The money (both coins and bills) is then transported to and dropped onto a second conveyor belt where the paper currency is "blown" off by a blower/vacuum system. The coins continue on to a vibrating coin-sorting grid. (The RTD separator is described in more detail in Reference *9*).

Money separators, such as the one used by RTD, are adequate to deal with moderate volumes of paper currency. Under heavy loads, bills may reach the coin-sorting grid and ultimately block coins from dropping through the grid. When this occurs, the

money-separating machine must be "cleared" and revenue security may be compromised.

Money separators should be viewed as a "Band-Aid" type of device that is inappropriate for any transit agency considering a solution to dollar-bill problems by implementing electronic fareboxes. Such devices exist to accommodate those transit systems that purchased single-compartment fareboxes. Ultimately, dual-compartment fareboxes are expected to obviate the need for such separators.

Mechanical Currency Counters and Sorters

A number of currency counters and sorters are available from a number of suppliers, mostly for the banking industry. The majority of these devices are simple document counters designed to handle currency, checks, coupons, food stamps, and other documents of various sizes. Most are intended for use in relatively benign environments, such as air-conditioned offices and banks, and are designed for relatively modest duty cycles. A few, however, are rated heavy-duty and some have been implemented into the transit industry.

Simple document counters address only a small part of the revenue-processing tasks, namely the 20 percent effort associated with actually counting the currency. They are of no consequence relative to the major effort required to unfold and flatten paper currency. In fact, mechanical currency counters tend to increase the amount of effort required in the flattening process because the devices require a relatively orderly stack of currency to avoid jams of the feed mechanism and to prevent miscounts. Most currently counters on the market today work best with currency that is referred to as "brick" quality or "teller" quality. These qualities mean the condition of the currency is such that it is clean, semi-transparent (light permeable), whole with no rips or tears, and has square corners with no foreign matter stuck to it. Clearly these conditions are not met in the transit environment.

Very recently, however, a new line of products, called currency discriminators, has entered the market. These devices were not developed for the transit industry but for the automated teller machine (ATM) operations in the banking industry. Currency discriminators are designed to sort unfit from fit (or brick quality) currency so that an ATM will be stocked only with currency of a quality that will not jam the machine. However, the key feature—insofar as potential transit application is concerned—is that these devices are designed to accept a wider range of bill qualities than traditional currency counters. Many of the ATM-specific features of these devices, such as the detection of double bills and half-bills and possibly the sensing of counterfeits, may be desirable even in a transit application. Other features, such as the sorting out of bills with dog-earned corners, would not be appropriate to transit revenue processing. Considerable tailoring of these devices, therefore, would be required for deployment in the transit industry.

Although these newer currency discriminators promise to be more effective than most traditional counters in dealing with currency of varying quality, they remain counters. Sorting and facing of bills must be performed manually. As a result, quite a few transit systems have expressed the opinion that by the time bills are unfolded, flattened, sorted, and faced, they might as well be counted manually, too. This view does not take into account that of all the mundane tasks associated with revenue processing, counting is the only activity that requires a modicum of concentration and quiet. For this reason, currency counters are considered desirable for transit agencies encountering modest volumes of dollar bills (weekly volumes in excess of 10,000 bills).

In addition to the variety of mechanical counters, automated devices are available for sorting (and counting) and for facing (and counting) paper currency. Sorting machines have virtually no value in the vast majority of transit applications. The frequency with which currency of denominations other than $1 is encountered is so small that the added expense of a machine with a sorting capability cannot be justified. It appears likely that most U.S. transit agencies can avoid sorting machines for the foreseeable future because the two-dollar bill remains a rarity and, according to Treasury reports, will not be marketed unless the dollar coin becomes successful. Canadian systems, on the other hand, face the prospect of substantial volumes of both one-dollar and two-dollar bills over the next few years because of the greater circulation of the Canadian two-dollar bill.

Facing machines (devices that accept bills in any orientation, provided they are stacked, and return bills facing in the same direction) are relative newcomers to the transit industry. One such device was unveiled in 1983 specifically for the transit industry. It operates on the principle of recognizing the orientation of each bill via an optical electronic camera. Each bill is classified into one of the four possible facing categories and diverted to a bin corresponding to that particular orientation.

Electronic Currency Counters

Electronic currency counters are extremely sensitive and accurate electronic scales used to weigh currency. Two basic varieties appear on the market. One is a single-scale device that directly weighs the currency in postage-scale fashion and computes the number of bills based on prescribed weight specifications. The second currency counter operates as a balance, measuring a stack of bills against a reference stack of bills of known quantity. The balance version of the electronic counter indicates the number of missing or extra bills.

The choice between the two types of scales depends on a number of factors. Banks are apparently satisfied with the direct-weighing scale. Transit agencies that have used it claim that it is not accurate. The difference of opinion is likely caused by the quality of the bills measured and the conditions under which they are measured. Banking experience is more positive because most measurements are made on bills of higher quality; e.g., verifying packets of money received from the Federal Reserve System. Banking operations also are performed in a relatively stable, benign environment. Transit circumstances are quite different. For this reason, the balance-scale version of the electronic counter is more suited to the transit environment. By using a reference stack of currency, the measurement can account for weight differences that may be caused by bill soiling, moisture content resulting from humidity changes, and so on.

Use of Private Contractors

The use of private contractors is an alternative to in-house revenue processing. This approach has been implemented by

several transit agencies including the Kansas City Area Transportation Authority, Bi-State Development Agency (St. Louis), and the City of Detroit Department of Transportation. At the Massachusetts Bay Transportation Authority (MBTA) a local bank performed all revenue-handling services at the transit facilities for several months in 1984 after a major theft operation was uncovered. In general, bills were separated from coins, bagged and tied, weighed on a scale for approximate value, and turned over to an armored car service for processing at its facilities.

A major disadvantage to contractor processing is that it does not necessarily resolve the currency problems associated with dumping the fareboxes. In addition, the transit agency loses direct control over the revenue-handling process, which may not be politically acceptable in some cities. With contractor services, the transit agency generally must rely on the contractor's integrity that the correct amount of money is reported. The Bi-State Development Agency resolves this issue, in part, by stationing a transit employee at the contractor's facilities during counting. In addition, the cost of contractor services is perceived to be high because they do not include the cost of sorting bills and coins, separating bad bills, etc. A range of costs has been reported. The contractor used in Kansas City charges for pick-up service but not for counting because it processes all deposits for the bank the transit agency uses. Bi-State Development Agency is charged 1.1¢ per bill, whereas estimates for the Detroit contractor range from 2¢ to 3.5¢ per bill.

The advantage to contractor service is that it eliminates the problems of obtaining, training, and supervising personnel to process the currency. The costs and responsibilities for obtaining bondable personnel are borne by the contractors. Because of the nature of their business, they can probably perform these functions more efficiently and effectively than can a transit agency. In addition, because they can guarantee turn-around time, an added benefit could be increased interest earnings at some transit agencies.

CHAPTER FOUR

ELIMINATING PAPER CURRENCY

The transit industry has also responded to the paper currency problem through efforts to reduce or eliminate it. A few transit agencies have vigorously pursued campaigns to ban paper currency from their systems. Others have sought to maintain fares at low enough levels to ensure that coins remained the dominant form of the collected fares. Borrowing heavily from European systems, other solutions include "new" methods of fare payment, such as fare prepayment or postpayment.

This chapter describes American and European experiences with these various options and discusses the advantages and disadvantages of each. The cost of alternative fare payment options and equipment requirements are also addressed.

BANNING PAPER CURRENCY

Early responses to the dollar-bill problem attempted to stem the influx of dollar bills by discouraging their use. Actions ranged from appeals to the public to outright prohibitions on the use of dollar bills.

In November, 1981, during the height of the publicity surrounding the dollar-bill problem, an APTA survey found that 38 percent of the transit agencies then banned the use of dollar bills for the payment of fares (*11*). More recent statistics on the number of agencies banning the dollar bill are unavailable but current trends suggest that following a brief period of increasing numbers of agencies with policies banning the dollar bill, the percentage is now declining slowly. At the time of the survey, several major systems—Los Angeles, Boston, Philadelphia, and Chicago—joined the ranks of those prohibiting dollar bills. A number of other transit agencies were on the verge of adopting similar policies and many did follow suit. However, public outrage dissuaded a number of others from pursuing the same course.

The history of attempts to ban paper currency has been a mixture of successes and failures. CTA began a campaign to ban the use of dollar bills in October, 1981. Its initial results were encouraging; dollar-bill use dropped from 300,000 bills a day to 40,000 (*8*). Gradually, use began to climb, and new campaigns were initiated. During this period, the CTA program received considerable press coverage, some highly negative. Stories of a lady with four children with no change being forced off the bus and of a lady being removed from a bus in 13° weather during a snow storm with the next bus not due for another hour circulated throughout the industry (*3*).

Philadelphia reported criticism from the media when it first aired its intent to ban dollar bills. But it was able to quiet the public response once the policy went into effect by using an extensive public relations campaign explaining the problem and the costs to the public. In Washington, D.C., WMATA considered banning the dollar bill but the concept collapsed when suburban Virginia commuters complained and threatened to stop riding rather than carry a pocketful of change. Los Angeles, expecting similar negative responses, lobbied for and received special fare subsidization from the California legislature (Proposition A) that permitted a temporary roll-back (until July 1985) to a 50-cent base fare.

The banning of paper currency does indeed lead to impossible circumstances that in the longer term tend to undermine the policy. The vehicle driver must simultaneously provide good

public relations for the transit agency and force compliance with the policy prohibiting dollar bills. The transit agency faces the problem of honest passenger error versus blatant attempts to defraud the system by those who do not wish to pay and thus have "only" a dollar bill. The transit agency, as a public agency with public responsibilities, faces a particularly difficult problem when it attempts to refuse legal currency for the payment of fares.

Still, programs to ban paper currency have been and can be successful—given the correct circumstances. New York, for example, has traditionally had few dollar-bill problems. Passengers in New York and much of New Jersey have always been conditioned not to use paper currency. New York's subway system is also close to most people in the city and a bus passenger who does not have change can, in many locations, descend to the subway, obtain change, and either ride the subway or return to take the bus. Other agencies have significantly reduced the dollar-bill volume through extensive public relations and astute marketing of not only the riding public but the nonriding community. The process requires dedication, finesse, and expense to achieve small victories, such as convincing a merchant near a transit stop that business would likely improve by welcoming change-seeking customers rather than turning them away.

Banning the dollar bill is not a viable long-term option. It requires constant attention and can involve considerable tangible and intangible costs. It should be considered only as an interim solution; i.e., a means to buy time until a more acceptable solution can be implemented.

SUBSIDIZED LOW FARES

Another short-term option is to maintain fares at a level low enough to retain a coins-only fare system, such as by lobbying for the type of concession that Los Angeles achieved in mid 1982 in securing Proposition A, which allowed SCRTD to return to a 50-cent base fare. Even if successful, this must be considered a reprieve and not a pardon from the dollar-bill problem. Given the present social (and political) climate, continued long-term subsidy at extraordinary levels appears unlikely and, even with substantial subsidies, fares will eventually be drawn higher and higher by even modest inflation.

To the extent that low fares also buy time, they are an appropriate objective for the transit agency facing the dollar-bill problem. This time can be used to consider the longer-term options, to select the particular option(s) that is (are) most appropriate, and to implement the option(s) with greater preparation and lower risk. Los Angeles, for example, has used its three-year "reprieve," which expires in July 1985, to move to a new generation farebox.

FARE PREPAYMENT ALTERNATIVES

Fare prepayment—tokens, tickets, and passes—has been part of transit fare collection since the earliest days of an organized transit industry. Perhaps the most notable and successful U.S. fare prepayment system is used in New York where tokens constitute 40 percent of all revenue. The fare collection alternatives that are currently under evaluation in New York continue the tradition of cashless fare payment via passes and magnetic tickets (*15*).

In the United States and Canada, fare prepayment has been credited with a variety of advantages including increased boarding speed and lower wear and tear (compared to multiple coins) on fareboxes, but, by and large, they have been adopted as conveniences for the passenger facing exact fares. Although sometimes promoted extensively, they are seldom embraced as a significant alternative to cash fares.

Such media have been promoted as passenger conveniences even when fares were extremely low; e.g., to replace the two/three-coin 15-cent fare with a single token. Use and availability increased modestly with each fare increase, particularly when fares advanced from 35 cents (two coins) to 40 cents (three coins) and from 60 cents (three coins) to 65 cents (four coins). However, the most significant increases in these prepayment instruments has been in more recent years, first as the result of the move to exact fares and now in response to the problems of paper currency.

European systems, by contrast, have adopted such alternative fares as the primary method of fare payment and, for more than a decade, have actively discouraged the use of cash for fare payment on their vehicles.

Tokens

Tokens are used by the least number of transit agencies. They are generally associated with larger North American systems, such as Toronto and New York, but some systems outside North America (e.g., Buenos Aires and Istanbul) and some smaller systems within North America (e.g., New Orleans and Harrisburg, Pennsylvania) make use of tokens. As a result of the problems of paper currency, token use has increased slightly in the past few years but is not expected to grow significantly.

In October, 1981, Chicago began selling bags of tokens at a discount of 5½ percent as part of its campaign to reduce the volume of dollar bills. Other agencies also began to "rediscover" tokens and to revive them at various levels of discounts. Tokens, however, are most commonly used where a flat fare is used and only where the fare structure is expected to remain relatively stable. Because tokens represent the value of a fare, they are frequently hoarded before anticipated fare increases, delaying the return the system expected to receive from the fare increase. Tokens also require the transit agency to establish a distribution network for token recirculation and to maintain a higher degree of revenue security and accountability than is required with coins.

Implementation of tokens involves several trade-offs. Because tokens must be recycled, any potential cost savings derived from their use will frequently be offset by the additional costs incurred in their redistribution. At the very least, a careful cost analysis of all costs must be undertaken before adopting tokens to ensure that benefits outweigh costs.

The obvious advantage of tokens is their coin-like physical features. As a result, they are compatible with existing fareboxes and with most coin counting/processing equipment. To the extent that they reduce the number of coins entering the system, they reduce wear and tear on both fareboxes and processing equipment and reduce maintenance costs.

One of the most significant disadvantages of tokens is their incompatibility with variable fare structures. Because tokens are best suited to flat-fare systems, their adoption represents a com-

mitment to a continuation of flat fares—and to relative fare stability. Tokens are not a short-term option because of the investments that must be made in procuring the tokens themselves, in setting up the procedures and equipment for processing them, and in establishing the necessary distribution network. Once a commitment is made to tokens it is very difficult to withdraw from that commitment. If a transit agency has any reason to believe it will move from a flat-fare system to a zonal system (or will add zones to its existing system), the token approach to paper currency problems is not advisable if only because it will inhibit such a transition. Given the current trends, most agencies are, therefore, likely to avoid the transition to tokens because of their stifling effect on future fare options.

Tickets

Tickets enjoy much wider use than tokens, especially outside North America. In fact, many European agencies are so decidedly ticket-oriented that even cash-paying passengers must buy a single-trip ticket from the driver to complete a trip.

Advantages and Disadvantages

Compared to tokens, tickets provide a number of advantages—and some unique problems. Theoretically, at least, tickets provide far greater fare flexibility. They can be printed in any denomination and thus can be used for different categories of passengers, different fare structures including zonal structures, and various incentive fares. Unlike tokens, tickets can be given expiration dates to prevent hoarding in anticipation of fare increases. Tickets also need not be recycled but can simply be discarded.

However, unless the driver can visually inspect the ticket, the passenger is afforded the same opportunity for fraud now available with dollar bills. If the driver collects (or punches) tickets, operations are slowed—and the driver is provided an opportunity for skim whenever a "live" ticket is encountered.

Tickets do require a distribution network plus security and accountability procedures comparable to tokens. Compared to the "one-time" minting costs of tokens, ticket printing costs are a continuing and recurring expense that frequently involves considerable waste. Sale of advertising space on tickets can help to recover these costs. Counterfeiting of tickets is also a distinct possibility.

The most significant problem with tickets is that they share many of the undesirable handling traits of paper currency. They reduce the volume of paper that will enter the farebox, but because the quality of the paper must be substantially lower than paper currency, farebox jams may be as frequent and, in some cases, present more of a problem as a result of the paper dust generated. Likewise, tickets reduce processing costs after the fare is paid but add significant "pre-fare" costs for printing, distribution, security, and accountability.

Ticket Handling in the United States

Although some transit agencies sell a punch-style of multi-trip ticket that is valid for a specified number of rides, the majority of the multi-trip tickets being used in the United States are tear-off tickets. Having the physical appearance of a single ticket, these tear-off tickets are actually strips of individual single-ride tickets; they are the ticket-equivalent of tokens.

Overall, the use of multi-trip tickets in the United States is very low because they are cumbersome for the operator to handle and because they typically are marketed solely for passenger convenience and without discounts. The tear-off tickets introduce a significant amount of paper into the system and thus complicate the farebox collection of fares and the handling and accounting of revenue. The punch-style ticket is impractical for most agencies because of the additional activity required by the driver; for many transit agencies, the extensive use of punch tickets on high-volume lines would result in significant service degradation caused by increased vehicle dwell time. Because few multi-trip tickets in the United States are discounted, passenger attraction to the convenience of the multi-trip tickets is frequently offset by the effort required to purchase the ticket. The measure of convenience afforded by the present multi-trip ticket may become quite marginal, for example, in some zoned systems that also require a cash supplement in addition to the multi-trip ticket.

European Ticket Procedures

The European approach to multi-trip ticketing, on the other hand, is quite different. Because European self-service systems provide special devices called validators or cancellers that the passenger uses directly to "validate" individual trips with the multi-trip ticket, the multi-trip ticket does not represent an additional driver burden or contribute to increased dwell time. In fact, the opposite is most often true; increased use of multi-trip tickets contributes to increased service productivity because the substitution of the validator for driver "validation" removes the requirement for front-door-only boarding. In high-capacity situations, the use of multiple validators divides the boarding queue and may significantly reduce dwell time.

In self-service systems, for example, the multi-trip ticket has considerably more appeal both to the European transit operator and the transit consumer than its U.S. counterpart. For the operator, multi-trip ticketing streamlines rather than complicates fare collection. The passenger in the self-service system gains not only the convenience of not having to pay cash for each trip and the financial benefit of the discount but also is rewarded by being allowed quick and easy access to the vehicle.

Although self-service represents the ultimate in prepayment, it is not implemented easily or inexpensively. The special equipment typically associated with self-service operations can be as expensive and as difficult to maintain as electronic fareboxes. To gain maximum benefit, vehicles must be designed to permit multiple boarding/alighting channels and passengers must be able to use any entrance or exit. Fare inspectors must be hired to control fare evasion and a delicate balance must be maintained between possible excessive inspection costs and excessive fare evasion. The Europeans have had considerable success with self-service as have North American light-rail systems but the concept has not yet been shown to be cost-effective in U.S. bus operations.

Passes

Transit passes (documents valid for an unlimited number of rides over a fixed time period) have had an up-and-down history. Various types of passes were common during transit's peak around World War II. Weekly passes were the most popular but a number of transit agencies offered monthly, weekend, and evening passes. The availability of passes began to decline along with patronage reaching a low in the mid 1960s and rebounding during the 1970s.

Pass use has grown significantly in recent years for a variety of reasons beyond exact-fare and dollar-bill problems. Passes have been shown to reduce boarding time by as much as 25 percent. Passes also have fewer distribution problems than either tickets or tokens. They are also viewed as yielding a desirable cash flow and promoting ridership loyalty. They have, however, brought up a whole new set of problems, some of which, such as counterfeiting, are so severe that by no means can passes be considered a worry-free solution to the dollar-bill problem.

Both North America and Europe experienced increased use of passes during the 1970s, for slightly different reasons. In the United States passes acquired the image of being a less cost-effective method of fare collection than cash during the period when private operators were eliminating passes in an effort to increase revenues. The trend to public ownership during the 1970s coincided with an increased willingness to encourage public transit that allowed passes to be given another chance despite their revenue disadvantages. Europe was at the same time experiencing the effects of similar political desires to reduce the cost of public transit. Europe, however, also had the additional incentive to simplify the fare collection process by reducing the use of tickets, which require validation in the European self-service mode of fare collection.

Advantages and Disadvantages of Passes

A number of advantages and disadvantages have been cited for passes. Passes increase boarding speed, provide economy and convenience to the user, promote ridership loyalty, and expand transit's marketing opportunities. On the other hand, passes can be viewed as discriminatory, major sources of revenue loss if substantial discounts are given, and subject to extensive fraud through counterfeiting and misuse. Passenger convenience has been the major stimulant to the introduction of passes until very recently. More and more agencies are now citing reductions in cash fares as the primary benefit of passes. Potential revenue loss appears to be the dominant concern of most agencies but costs associated with marketing and distributing passes and pass counterfeiting are growing concerns.

Pass Use in the United States and Canada

Period passes in the United States and Canada continue to be predominantly simple flash passes with little or no accompanying identification of the user. This appears to be changing gradually as more and more agencies seek to counter such problems as high incidences of passes being transferred between a number of users (e.g., through the bus window) and pass counterfeiting. Philadelphia, for example, marks its passes to identify the sex of the purchaser and Los Angeles issues passes bearing the photograph of the purchaser. OC Transpo in Ottawa-Carlton, Canada is one of the few agencies that uses a two-part pass consisting of a photo identification card and a monthly pass. To be valid, the passenger must present both parts to the driver and the identification number of the photo portion of the pass must be written on the monthly pass portion of the document. The OC Transpo pass is, in fact, more representative of the passes used in Europe than the typical North American pass.

Pass Use in Europe

By comparison, the typical pass in European systems is quite complex. Specific identification of the user is almost always associated with the pass. In Paris, for example, the Orange Card bears the photograph of the user plus the bearer's national identity card number and other identifying characteristics. The range of passes offered is also quite varied, with different passes and different prices for various categories of users, for different time periods, and for different trip purposes. Munich, West Germany, for example, offers more than 60 distinctly different passes covering nearly all conceivable circumstances. Pass use in Europe is also quite extensive, with many systems experiencing from 50 percent to as many as 75 percent of its trips being made with passes.

Prepayment Costs

Prepayment, whether token, tickets, or passes, involves three types of costs: (a) the cost of administering the program, (b) the cost associated with the explicit and implicit discounts with prepayment compared to cash fares, and (c) the cost of fare evasion and fraud.

Administration Costs

Studies performed for UMTA have identified 11 cost categories associated with a prepayment program: preparation, delivery, sales, accounting/recording, design, printing, inventory, handling, advertising, administration, and overhead (*16*). Cost can vary considerably within each of these categories for each of the three prepayment types, depending on the size of the transit system and exactly how the prepayment program is set up and administered. The cost of each prepayment instrument (roll or package of tokens, ticket booklet or multi-ride ticket, or pass) is higher, on average, at larger transit agencies (86 cents) compared to small or medium agencies (14 to 44 cents). Unit costs (1981 dollars) at selected transit agencies for prepayment instruments ranged from \$0.54 to \$1.44 for tokens, \$0.11 to \$2.96 for tickets, and \$0.34 to \$1.02 per monthly pass. In general, a typical prepayment program costs about 6 cents for every prepaid dollar earned; the average cost per trip is 2.2 cents (*16*).

Discounting Costs

Some degree of discounting is necessary with prepayment if substantial use is to be encouraged. With tokens, tickets, and punch cards the discount is in the form of a fixed rate for a fixed number of rides. Time-limited plans, such as pass programs, provide an implicit discount that is variable because it depends on the frequency of use.

Explicit discounting of tokens and tickets is far more common in Europe than in North America. U.S. and Canadian transit agencies frequently offer no discount or only modest discounts of from one to five percent on these types of fare prepayment (Table 1 presents the guidelines recently appearing in a guide for U.S. transit managers.) European ticket discounts are substantial (Table 2). As a result of this difference, Europe is able to attain a high percentage of trips by passengers using tickets. North American systems, with notable exceptions, have relatively modest ticket (and token) use.

TABLE 1

PROPOSED PREPAYMENT GUIDELINES FOR SELECTED TARGET GROUPS (*17*)

Target Group	Type of Plan	Pricing Guidelines
Commuter	Tickets, tokens, and punch cards	No discount if less than 20 trips are purchased in advance.
		1 to 5% discount if more than 20 trips are purchased in advance.
	Monthly passes	52 to 60 times the peak fare in large cities.
		43 to 52 times the peak fare in small cities.
		40 to 45 times the peak fare for distant commuters.
	Annual passes	11 times the appropriate monthly pass price.
	Weekly passes	10 to 15 times the peak fare.
Shopper	Off-peak day passes.	2 to 3 times the off-peak fare or 1 to 2 times the peak fare.
	Off-peak tickets	No discount from existing off-peak fare or 10 to 20% discount from peak fare.
College Student	Tickets	No discount if less than 20 trips are purchased in advance.
		1 to 5% discount if more than 20 trips are purchased in advance.
	Off-peak tickets	10 to 20% discount from unrestricted prices.
	Semester passes	3½ to 4 times the appropriate monthly pass price.
	Off-peak semester passes	10 to 20% discount from the appropriate unrestricted semester pass price.
Transit Dependent	Off-peak tickets and permits	50% discount from peak fare for elderly and handicapped according to federal law.
		10 to 20% discount for others.
Tourist	Day passes	3 times the peak fare for each day of validity.
	Off-peak day passes	3 times the off-peak fare for each day of validity.
	Off-peak tickets	Off-peak fare or 10 to 20% discount from peak fare.

TABLE 2

TYPICAL EUROPEAN TICKET DISCOUNTS (*18*)

City	Multi-Trip Discount (%)
Bern	12.5 - 20.4
Brussels	25.0 - 42.5
Cologne	33.0
Copenhagen	25.9 - 55.5
Dusseldorf	30.5 - 33.3
Geneva	4.2 - 8.3
The Hague	16.3 - 39.7
Milan	54.2 - 73.7
Munich	16.7
Paris	0.0 - 37.5

In both North America and Europe, the (implicit) discounts given on passes is usually greater than other prepayment media. As is the case with tickets, however, the European discount is far greater than the discount given for its U.S. counterpart. U.S. pricing for monthly passes is typically at the levels shown in Table 1—from 40 to 60 times the peak fare. In Munich, for example, the most common pass, the Center Zone pass, is priced at 25 times the cash fare and 30 times the multi-trip ticket fare. Brussels prices its monthly pass at 24 times the cash fare. Again, European pass use is significantly greater as the result of the increased economic incentive for its use.

It is quite evident that on the basis of the above comparison, the economic incentives provided by European systems to passengers promote substantial use of prepayment. Comparable discounts in the U.S. and Canadian transit industry would be expected to yield similar shifts to prepayment. However, deep discounting of this order of magnitude would meet stiff resistance in the United States because of farebox revenue requirements.

Prepayment Equipment

European operations are typically supported by a wide range of automated devices. Most offer ticket vending machines from which the passenger may purchase single-trip and multi-trip tickets. Nearly all provide special devices for the validation of these tickets for individual trips, and some incorporate a variety of other automated and semi-automated devices designed to support driver and agent ticket sales, to provide fare and schedule information, to facilitate revenue accounting, and to monitor system performance. The following describes some of the typical features of the hardware currently being used in many European systems.

Ticket-Issuing Equipment

European systems are highly ticket-oriented. Tickets are available from numerous sources—ticket-vending machines, drivers, transit agents, and other outlets, such as newsstands, shops, and banks.

The ticket-vending machine is a common feature in European operations. Located at transit stops, station and transfer areas, and, in some instances, on the transit vehicle itself, the ticket-vending machine provides for self-serve purchasing of all types of tickets. In general, single-trip tickets and multi-trip tickets are sold through different machines. However, newer generations of machines being offered by various manufacturers combine these functions into a single unit.

Ticket-vending equipment ranges from the very elementary to the very sophisticated. Some units, such as those used in Brussels, are primarily mechanical devices that accept only a single coin denomination and dispense a single type of ticket. These machines are stocked with preprinted tickets and no printing or other operation is performed by the machine. The more sophisticated machines, such as those recently installed in Stuttgart, dispense a variety of ticket types and print on the ticket stock at the time of purchase whatever information is needed to produce different types and values of tickets. Machines developed for a few European rail systems issue special "defined-destination" tickets and, therefore, offer scores of selections for the passenger using the unit. Most of these more complex machines are microprocessor controlled and incorporate needle printers to facilitate changes in fare structures or ticket design.

Ticket (and token) vending for bus transit is beginning to appear in the United States to a limited extent. Sacramento currently is experimenting with three vending machines that dispense strips of single-ride tickets. Kalamazoo, Michigan has installed several machines to dispense multi-ride tickets. Portland, Oregon installed several machines that dispensed both single-ride and multi-ride tickets.

Ticket-Validation Equipment

A primary characteristic of most European fare collection systems is the random inspection of passengers to ensure that each has paid the correct fare for the trip that is being taken at the time of inspection. Consequently, each passenger must be provided a document that can serve as proof of payment during such an inspection.

Passes inherently contain sufficient information to serve as proof of payment and therefore require no action by the passenger before the trip. Similarly, single-trip tickets issued by one of the driver-operated machines are sufficient proof of payment if they contain enough information (e.g., time and date) to match the ticket to the actual trip being taken. Other fare documents, such as single and multi-trip tickets purchased from machines and agents, must be validated in a special device just before the trip to provide this information.

The device used to provide this proof of payment is a validator (also called a canceller). When a passenger inserts a ticket into the validator, appropriate information is printed on the ticket to show when and where the validation was made. Validators differ markedly according to the type of information printed on the ticket, the type of checks that are made to ensure that a legitimate ticket is being used, and the type of alterations made to the ticket during the validation process.

Validators may be located either at wayside locations or on board the transit vehicle. Most Swiss systems use wayside validators and usually incorporate them in the vending machine enclosure. Most other European agencies prefer to place validators on the vehicles; one or two validators are located near each vehicle doorway.

The most elementary form of validation is that which accompanies a fare policy allowing unlimited travel within a specified time period after validation. With such a fare policy, only time/date information must be supplied during a validation. Lyon, France, for example, uses a validator that will time/date stamp any piece of paper that fits into the validator throat; no check of ticket legitimacy is made during validation. Multi-trip tickets are sold in the form of booklets of single-trip tickets.

Geneva's validators are similar to Lyon's in that very limited information is printed during validation. Because Geneva also offers a "short-trip" ticket that entitles the bearer to travel up to three stops from the point of validation, the location of the validation is also printed. Geneva's validators also incorporate a guillotine device that clips a small section of the ticket during validation so that a different line is printed on each subsequent ticket insertion into a validator. The guillotine feature permits the use of a single document for multi-trip use without the passenger having to fold or orient the ticket to ensure that the information is stamped at the correct location on the ticket. Copenhagen's new machines employ a similar guillotine feature. They also electronically verify that the document inserted into the machine is a valid ticket; conductive-ink strips are printed on the back of each ticket. Although Copenhagen is using this feature to reduce fraud and counterfeiting, other systems are considering the feature as a means of counting the use of different types of tickets. Other validators on the market use reflective strips on the ticket to facilitate this counting.

In 1982, the Tri-County Metropolitan Transportation District of Oregon (Tri-Met) in Portland equipped its entire fleet of more than 600 buses with such validators as part of an UMTA-sponsored demonstration of the European style of fare collection known as self-service. The demonstration was terminated in early 1984 for a variety of reasons including equipment reliability problems and fare evasion problems. However, there is continued interest in such devices and a number of manufacturers (see Appendix) have entered the U.S. market to supply such equipment not just for self-service operations but also for simple prepayment approaches, i.e., to substitute for driver punching while maintaining overall driver supervision and control.

Pass Equipment

Most European transit agencies distribute period passes through a variety of outlets, usually on a concession basis. In most cases, printing and accounting for these period passes are supported by a device similar to a cash register. Recognizing that many transit agencies are facing increasing resistance by concessionaires to handling greater numbers and types of period passes because of the transaction time (and cost) involved, several manufacturers are investigating a new line of products to support this pass distribution network. One machine, for example, prints a new period pass using data magnetically encoded

on the permanent I.D. portion of the pass; thus, renewals of period passes can be completed in a fraction of the time of existing procedures.

Such automated approaches to pass distribution have received little interest in the United States because of more pressing concerns, namely, pass counterfeiting and fraudulent uses of passes. U.S. transit systems have taken a succession of steps to avoid these problems including the printing of passes on special reflective paper and the inspecting of passes under special lights or lighting conditions. Considerable interest has developed in the past few years in the area of machine-readable passes and tickets. In 1982, San Diego Transit conducted an experiment with on-board pass readers. Although the experiment did not lead to implementation, the results were sufficiently encouraging that one U.S. farebox manufacturer now offers a pass reader as an integral module in its electronic farebox.

POSTPAYMENT

Postpayment of transit fares as a substitute or supplement to cash payment has been proposed and experimented with in a variety of forms. In general, bus passengers charge rides by inserting a special farecard into a reader on the bus. At the end of each month, an itemized statement is prepared and forwarded to the passenger for payment.

Postpayment Demonstrations in the United States

The Urban Mass Transportation Administration's (UMTA) Office of Service and Management Demonstrations has demonstrated postpayment at several small transit agencies. With UMTA support the Merrimack Valley Regional Transportation Authority (MVRTA) is running a postpayment demonstration called Charge-A-Ride in Haverhill, Massachusetts, a city of 47,000 people. The prime objective of the Charge-A-Ride demonstration is to test the feasibility and public acceptance of automated billing under general revenue conditions. Specifically, the demonstration seeks to achieve a 20 percent market penetration. Secondary objectives are to determine if on-board cash handling can be reduced, new riders can be attracted, transit use by current riders can be increased, or data collected can be useful for planning and marketing transit services.

Two previous demonstrations that used similar technology were conducted with UMTA's support in Connecticut's Lower Naugatuck Valley, and in Oregon's tri-county region around Portland. The prime objective of the Naugatuck demonstration was to provide a mechanism for a variable subsidy to elderly, handicapped, and other clients of health and social service agencies, although the general public was not specifically excluded. The prime objective of the Portland demonstration was to serve the mobility disadvantaged with a fleet of special vehicles where the cost of rides would be paid monthly by the social service agency sponsoring the client.

Advantages and Disadvantages of Postpayment

Postpayment is a potential solution to transit agency cash handling problems. The technology required is mature and demonstration programs have shown that postpayment offers superior convenience and flexibility to the patron and the system operator. The convenience of postpayment could expand transit agency marketing opportunities in areas such as transit subsidies by employers. However, implementation of postpayment could pose difficult administrative problems. Extensive use of credit would interrupt the normal cash flow of a transit agency and would require significant changes in accounting and financial procedures. Credit cards present transit agencies with the problems of card holder identification, account verification, and control of fraud, theft, and uncollectable charges. Attempts to institute procedures that would maintain control of cards and reduce operator liability could be costly and ultimately reduce passenger convenience.

CHAPTER FIVE

CONCLUSIONS

Table 3 summarizes the relative costs associated with a number of fare collection alternatives in each of several major cost categories. The table illustrates the general lack of a clear-cut choice. Each alternative presents a number of trade-offs that must be viewed in light of specific site conditions and circumstances.

Fare collection decisions are, and will continue to be, decidedly site-specific. The economics of different fare collection techniques will largely depend on specific site characteristics, such as system structure and passenger demography. For example, a radially oriented transit system with high commuter volumes might expect to experience lower overall costs associated with

TABLE 3

COMPARISON OF FARE COLLECTION COSTS

Fare Collection Method	Application	Administration (Excluding Bill Handling)	Dollar-Bill Handling	Discount	Fare Evasion and Fraud	Maintenance
Drop-type Fareboxes	Status quo	◒	●	N/A	●	◒[a]
Tokens	Conventional brass tokens	◒	N/A	●[b]	◒[a]	○
Tickets	Tear-off tickets	◓	N/A	●[a]	◒	○
	Machine-validated tickets	●	N/A	●	○	◒[a]
Passes	Conventional flash pass	◒	N/A	◓	●[a]	N/A
	Anti-counterfeit flash pass	◓	N/A	●	○	N/A
	Machine-verified pass (read-only)	○	N/A	●	–	◒[a]
Electronic Fareboxes	Dual-compartment bill stacking	◒	○	N/A	○	◒
	Data recording and audit system	◒	○	N/A	○	◓[a]
Self-service	Driver monitored	◓	N/A	●	◓	◓[a]
Postpayment	Transit-issued card	○	N/A	◓	○	◓[a]

Costs:
- ● > $0.05 per revenue dollar received.
- ◓ $0.03 to $0.05
- ◒ $0.01 to $0.03
- ○ $0.005 to $0.01
- – Negligible
- N/A Not applicable

[a]Costs may be lower in some circumstances.
[b]Varies according to transit agency policy.

passes than a system that did not share these characteristics. Administrative costs might be lower because fewer distribution outlets may be required and discounting costs may be lower because convenience may be valued as significantly as price by the typical purchaser.

Each alternative must be examined in light of a transit system's own unique circumstances. For most transit systems, the choices are either (a) to continue with the existing fareboxes and emphasize prepayment heavily or (b) to buy the latest generation of fareboxes. Continued reliance on drop-type fareboxes without substantial prepayment is impractical except in unique circumstances. Self-service, although quite successful throughout Europe and on North American light-rail systems, has not yet been proven effective on North American bus operations. It represents a high-risk decision that must be approached with caution. Postpayment remains only a possibility because at present neither the technology nor the procedures have been demonstrated in transit applications to the point that it can be considered an economically viable present-day solution.

The choice between prepayment and electronic fareboxes is a difficult decision. Economic factors are only a part of the decision process. Political, social, and historical factors frequently dominate the selection of a particular approach. Economically attractive approaches to prepayment, such as instituting a premium for cash fares versus discounts for prepayment (a common approach in Europe) may not be politically or socially acceptable. Capital intensive alternatives, such as new fareboxes, are favored by the cost-sharing features of capital investment.

There is no single or "best" solution to the dollar-bill problem. Industry momentum appears to be building in the direction of the electronic farebox as the "answer" for the longer term. A year or more may be necessary before enough experience is gained with the latest generation of fareboxes to determine if they adequately meet these needs.

In the much longer term, more radical approaches must be seriously considered. Self-service and postpayment represent significant departures from the current approach to fare collection. They are not immediate options but they deserve to be studied, evaluated, developed, and tried so that when such changes are needed, the technology and the procedures associated with them are mature enough that they can be adapted.

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APPENDIX

MANUFACTURERS AND SUPPLIERS OF REVENUE-RELATED EQUIPMENT

Manufacturer	Location	Equipment					
		Ticket Dispensers	Ticket Validators	Bill Verifiers	Card/Pass Readers	Cash Dispensers	Revenue Counters
AB Almex	Stockholm, Sweden		●				
Alta Technology, Inc.	Stamford, Connecticut	●	●		●		
AMCARD Systems, Inc.	Hudson, Massachusetts		●		●		
Ardac, Inc.	Willoughby, Ohio			●			
Autelca, Ltd.	Bern, Switzerland	●	●				
Automatic Revenue Controls	Hertfordshire, England				●		
Autoscan Systems, Inc.	Philadelphia, Pennsylvania	●	●				
Billcon International, Inc.	Compton, California						●
Camp	Paris, France	●	●		●		
Concord Computing Corp.	Bedford, Massachusetts			●		●	
Control Systems Ltd.	Uxbridge, England	●	●				
Crouzet	Valence, France	●					
Elcom Industries	St. Louis, Missouri				●		
EMI Data Systems	Garrison, Maryland				●		
Hamilton Scale Corp.	Toledo, Ohio			●			
Heinrich H. Klussendorf	Berlin, W. Germany	●	●				
Inter Innovation, Inc.	New York, New York					●	
Litton RCS Sweda	Milan, Italy	●	●				
Mag-Tek	Carson, California				●		
Musashi Co. Ltd.	Tokyo, Japan						●
Recognition Equipment, Inc.	Dallas, Texas						●
SAF Systems and Forms	Chicago, Illinois						●
Sensor Engineering Co.	Hamden, Connecticut				●		
Standard Change-makers	Indianapolis, Indiana			●			
Standard Johnson Co.	Brooklyn, New York						●
Synergistics, Inc.	Natick, Massachusetts				●		
H. J. Theiler	Spartanburg, South Carolina	●	●				
Ticket Equipment Ltd.	Cirencester, England	●	●				
Xico, Inc.	Santa Monica, California				●		

Electronic Fareboxes

Cubic Western Data
5650 Kearney Mesa Road
San Diego, California 92111

General Farebox, Inc.
751 Pratt Boulevard
Elk Grove Village, Illinois 60007

Add-On Bill Acceptors

National Rejectors Industries
P.O. Box 1550
Hot Springs, Arkansas 71901

Rowe International, Inc.
75 Troy Hills Road
Whippany, New Jersey 07981

Currency Processing Equipment

Abbott Systems, Inc.
375 Fairfield Avenue
Stamford, Connecticut 06902

ATS Money Systems
Two Executive Drive
Fort Lee, New Jersey 07024

Brandt, Inc.
P.O. Box 200
Philadelphia, Pennsylvania 19134

Cummins-Allison Corp.
891 Feehanville Drive
Mt. Prospect, Illinois 60056

The Federal Bill Counter Co.
126 Lafayette Avenue
Laurel, Maryland 20707

Magner Corp.
41 West Street
Middlefield, Connecticut 06455

Mosler Safe Company
An American Standard Company
1561 Grand Boulevard
Hamilton, Ohio 45012

Technitrol, Inc.
1952 E. Allegheny Avenue
Watertown, Wisconsin 53094