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of Transportation
**Urban Mass
Transportation
Administration**

Self-Service Fare Collection on the San Diego Trolley

Final Report
May 1984

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16. Abstract

The San Diego Trolley (owned by the Metropolitan Transit Development Board) began operations in July 1981 using self-service fare collection (SSFC). Passengers must have proof of payment consisting of a single-ride ticket bought at a vending machine located at one of the 18 stations, a multi-ride ticket validated at one of the same machines, a transfer, or a monthly pass. About one-third of riders are checked by a team of inspectors who issue citations, or notices to appear in court, to fare evaders. The usual penalty for fare evasion is to forfeit $20 bail plus a $10 court fee. The 33 ticket machines have performed well in the opinion of Trolley staff, with a record of better than 96% in-service availability. Analysis of boarding times indicates that SSFC on the Trolley saves about 3.4 minutes per 16-mile run. On the average, 0.5% of passengers checked do not have proper proof of payment. The use of court citations has proved workable, although 20% to 40% of cited passengers ignore the citations indefinitely. Passengers have generally positive attitudes toward the SSFC system. Total annual cost (including annualized capital) for SSFC has been estimated at $444,000 or $.11 per passenger. Conventional fare collection would have much higher operating costs and lower capital costs.

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PREFACE

This report was prepared by Crain & Associates, Inc. under contract to the Transportation Systems Center (TSC) of the U.S. Department of Transportation, under sponsorship of the Service and Methods Demonstration (SMD) Program of the Urban Mass Transportation Administration. The TSC project evaluation manager was Robert Casey. He and Lawrence Doxsey, also of TSC, were particularly helpful in shaping the analysis of boarding times reported in Chapter 3. The UMTA project manager was Stewart McKeown.

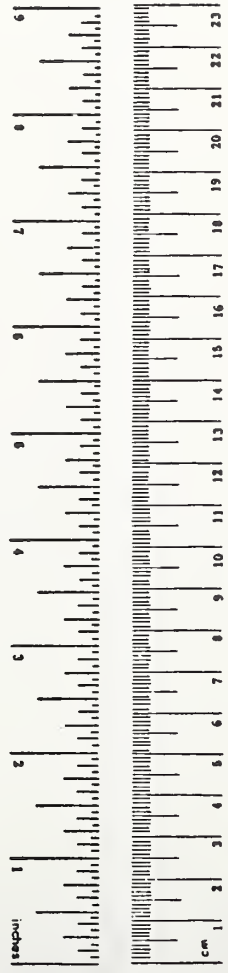
The Metropolitan Transit Development Board (MTDB) of San Diego provided all the data used in the report, except for the Boston boarding time data which were provided by the Massachussetts Bay Transportation Authority (MBTA) and Cambridge Systematics, Inc. The staff of MTDB were enthusiastically cooperative, including especially Robert Robenhymer (Senior Transportation Planner) and Dan Portuguez (Supervisor of Fare Inspection). Staff of San Diego Trolley, Inc. (SDTI), especially Ed Foster (Supervisor of Maintenance) were also very helpful. Bob Parrott formerly of the San Diego Association of Governments (SANDAG) supervised the on-board surveys and ride checks and associated data reduction.

The report was written at Crain & Associates, Inc. by David Koffman with major contributions by George Rhyner (Chapter 5 and computer programming) and Robert Trexler (Chapter 2). Molly Hughes, Ana Chou and Maryjeanne McAteer typed the report.

METRIC CONVERSION FACTORS

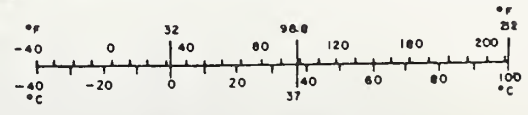
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^3	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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EXECUTIVE SUMMARY

INTRODUCTION

The San Diego Trolley began operations on July 26, 1981 as the first U.S. transit system to use self-service fare collection (SSFC). The Service and Methods Demonstration Program (SMD) of the Urban Mass Transportation Administration (UMTA) awarded the Trolley's owner, the Metropolitan Transit Development Board (MTDB), a grant to conduct an evaluation of SSFC. The Transportation Systems Center (TSC), in its role as evaluator of SMD projects, contracted with Crain & Associates, Inc. to advise MTDB on data collections and prepare this report. The evaluation relied on records of operations, maintenance, expenditures, operating reliability, enforcement, and the history of decisions leading to the designs and procedures now in use. MTDB conducted an on-board survey of its passengers and a study of boarding times. A study of boarding times on two Boston light rail lines was conducted for comparison purposes.

DESCRIPTION

The Trolley runs 16-miles, with 18 passenger stops, between downtown San Diego and San Ysidro, at the border with Mexico. Trains run every 20 minutes, seven days a week, from 5:30 AM to 8:30 PM. Each passenger must have one of five proof of payment instruments before boarding the Trolley: a single ride ticket purchased from one of the ticket machines at each station; a ten-ride or two-ride ticket validated at the same ticket machine; a transfer; or a regional monthly pass. Uniformed inspectors can request a passenger to show his or her proof of payment on board the Trolley and issue citations to those without the proper proof. Ridership averages about 11,000 trips daily. Ridership is heavier in the summertime and includes many tourists.

EQUIPMENT

Thirty-three ticket machines are distributed among the 18 stops and stations. They vend regular full fare tickets ($1.00), transfer upgrade tickets ($.20), elderly and handicapped tickets ($.40) and Centre City tickets ($.25). The machines do not accept dollar bills and do not make change. Each ticket vended is coded with the machine number, date, time and fare type. The machines also have a slot for validating multi-ride tickets by printing the same information on them and slicing off a corner of the ticket. A ticket or validation is good for two hours from the time of issue, travelling away from the issuing machine.

The ticket machines were purchased from Autelca AG, of Guemligen/Berne, Switzerland, following a competitive procurement. The vending part is of state-of-the-art, self-diagnosing, electronic design. The validator is a more conventional, electromechanical design. Additional equipment includes four change machines.

Trolley staff are pleased with the reliability of the ticket machines. The rate of ticket dispenser failures declined over the first year and a half of operations as staff learned more about the machine. Early problems included problems with ticket paper, cash box overflow, and coin verifier problems. During the wet winter of 1983, problems surfaced related to driving rains and wet coins. By early 1983 the single-ticket dispensers were experiencing about one failure per 12 machine days of operation or 2600 transactions. The multi-ride ticket validators' reliability has fluctuated considerably, settling at around one failure per 25 machine days of operation or 900 transactions. Validator problems have included printing the wrong date or time, and ticket jams.

Most of the time a trolley employee is engaged in repairing or maintaining the ticket machines. The average failure is fixed 40 minutes after it is reported. Making conservative assumptions about the time between failure and repair (including time for failures to be reported or discovered), it appears the dispenser and the validator have records of about 96% and 98% in-service availability respectively.

TRANSIT OPERATIONS

SSFC was expected to speed passenger loading because passengers do not need to pause to pay a fare, because the driver's seat does not need to obstruct traffic, and because passengers can get on and off through multiple doors. Measurements of boarding times were conducted on the San Diego Trolley and two light rail lines in Boston to determine whether SSFC speeds boarding, reduces travel time, or saves on equipment requirements. Based on a multiple regression analysis, each additional boarding and deboarding passenger in San Diego adds 0.7 and 0.6 seconds respectively to total dwell time. In Boston, with on-board fare collection, each boarding cash-paying passenger adds about 3.1 seconds, each boarding non-cash paying passenger about 1.9 seconds, and each deboarding passenger about 1.6 seconds to total loading time.

On average, conventional on-board fare collection would add about 3.4 minutes to the average trolley run. A more useful figure for scheduling purposes is that conventional fare collection would probably add about five to six minutes to the 90th percentile of Trolley run times. At the Trolley's scale of operations, it is not clear whether or not additional vehicles would be needed to maintain the present schedule. Conventional fare collection would add about 2.4 minutes to the average passengers' on-board travel time.

Coordinating fare payment with other modes has been a minor problem. Some passengers are confused by a requirement to purchase a $.20 transfer upgrade ticket from the vendomats when transferrng to the Trolley from a local bus line. Transfers from express buses require no upgrade.

Security in cash collection has not, so far, been a problem. The system does require collection of coin vaults from widely separated stops from one to three times a day, depending on the stop. There is no security problem in distributing ticket stock as blank ticket stock is considered worthless.

ENFORCEMENT

MTDB employs five full-time ticket inspectors, of whom four ride the Trolley most days. The inspectors ride randomly within assigned sectors, checking between 33% and 44% of all riders each month. On the average, 0.5% of passengers checked are found without proper proof of payment; of these, 66% receive a citation, or notice to appear in court. Cited passengers can forfeit bail of $20 plus a $10 "penalty assessment" or go to court. About a quarter pay the fine immediately and another quarter go to court. Most of those who go to court plead guilty and pay a reduced fine. About half of the evaders do not respond to the citation and are sent notice of a warrant. An uncertain proportion of cited evaders (from 20% to 40%) ignore the notices indefinitely and most of the remainder pay fines averaging $37. Of all cases that go to court, 21% are dismissed. The inspectors exercise discretion in citing the elderly and persons from out of town. Instead of citing a passenger, an inspector can issue a warning and allow them to get off and buy a ticket. They can also hand cancel multi-ride tickets.

Repeat offenders are a minor but continuing problem. As of mid-1982, MTDB knew of 232 repeat offenders, or 4% of all passengers cited. In principle, a repeat offense is a misdemeanor punishable by a fine up to $500, six months in jail, or both. The few repeat offenders who had been brought to court by mid-1982 were mostly fined $20. In a few serious cases, offenders have received fines of up to $100 and even short jail terms.

PASSENGER ATTITUDES

Passengers understand SSFC sufficiently to use it for the trips they make. Many passengers do not understand features they do not use, such as transferring and multi-ride tickets. Many passengers are not familiar with the details of the enforcement system, particularly the penalty for fare evasion. A majority of first-time riders, such as tourists and out-of-towners, do not

understand the enforcement system. However, nearly 90% of all passengers, including first time riders, regard the instructions on paying and using the ticket machines as clear. MTDB has instructed the ticket inspectors to use discretion in dealing with tourists and other non-residents who do not have proper proof of payment. Spanish speakers do not have any special problems in understanding the system.

Most passengers have a positive attitude toward SSFC, stating they prefer it to conventional fare collection and believe it is faster and more convenient. Only 22% of repeat riders believe too many passengers get away with riding for free; 29% think the $20 fine is too high; 29% find being checked annoying or embarassing.

The most frequently noted "disadvantage" of SSFC was the perception that more people cheat (24% of repeat riders). The time needed to buy or validate a ticket at the station was checked as a disadvantage by 18% of the repeat riders. Most passengers, however, continue to use single-fare tickets, although MTDB has hoped to convince a majority to use some form of pre-payment.

COST

Capital costs include $715,000 for 34 ticket machines; $10,500 for four change machines; $17,000 for two vans to collect cash and maintain the ticket machines; and $6000 for ticket inspectors' radios. Total capital costs were $749,000 including sales tax.

Annual operating costs include $65,500 for revenue collection and processing; $73,500 for maintenance; $15,600 for supplies; $11,300 for a telephone alarm connection between the ticket machines and central control; and $186,000 for enforcement. Revenue from fines exceeds estimated losses from fare evasion by $1,700, bringing total operating costs to $350,000.

If capital costs are annualized at a 10% discount rate, with a 20-year life for the ticket and change machines, a 2.5-year

Costs were also estimated for the hypothetical use of conventional, on-board fare collection on the Trolley. Capital costs for car modifications, fareboxes and central cash processing would be $126,000, much less than for SSFC. Operating costs for extra drivers and maintenance would be $604,000, much more than for SSFC. Total annualized cost for conventional fare collection would be $639,000, or $195,000 more than for SSFC. If lower-paid conductors could be used instead of extra drivers, most of the cost difference might be removed. On the other hand, an increased fare evasion rate and additional cash processing costs with conventional fare collection could increase the cost difference.

TRANSFERABILITY

The San Diego Trolley's experience clearly establishes the workability of SSFC in an American setting. Factors to consider in applying this experience to other transit systems include:

1. MTDB had a freer hand in procurement of foreign-manufactured equipment because no Federal funds were used.

2. MTDB uses wayside (as opposed to on-board) vending and cancellation which makes it harder for fare evaders to avoid detection.

3. Relatively few, widely-spaced stops on the Trolley may make it easier to catch fare evaders, and also makes the use of wayside vending and cancellation cost-effective.

4. The Trolley seems to have a special positive image for many people.

5. The scale of the Trolley's total operation is small compared to many transit systems.

6. In new applications there would be differences in costs due to inflation, and differences in wage rates in other transit systems.

1. INTRODUCTION

1.1 BACKGROUND

The San Diego Trolley, which began service on July 26, 1981 is the first U.S. transit system to use self-service fare collection (SSFC). The Trolley has been the object of considerable interest by other transit agencies considering use of SSFC. As a result, following an application from the Trolley's owner, the Metropolitan Transit Development Board (MTDB), the Office of Service and Management Demonstrations (SMD) of the Urban Mass Transportation Administration (UMTA) awarded grant number CA-06-0158 in the amount of $100,000 to MTDB on April 20, 1981, for the purpose of evaluating the self-service fare collection system in use on the San Diego Trolley. The Transportation Systems Center (TSC), in its role as evaluator of SMD projects, designated Crain & Associates Inc. to work with MTDB to produce the evaluation.

1.2 ISSUES AND APPROACH

Various forms of SSFC have been adopted by many European transit systems. More recently several Canadian cities have turned to SSFC. Experience in these applications suggests that SSFC can provide major benefits in cost savings, passenger convenience, improved service productivity, and the potential for more flexible fare structures. The concept has been under study for some years in the United States. In late 1982, the Tri-Metropolitan Transit District of Portland, OR, began SSFC on its bus system. This project is being funded by SMD and will be the subject of an evaluation report published by TSC. Other transit systems are considering or planning to use SSFC in the near future.

The San Diego Trolley was the first U.S. transit system to implement SSFC. Thus, the Trolley provides an opportunity to test whether SSFC in the United States can provide the benefits ascribed to it in other countries. The evaluation emphasizes testing the practical importance of this fare collection method for U.S. transit properties.

Because the Trolley was designed and built to use SSFC from the start, a direct comparison of operations with conventional fare collection on the same service was not possible. Instead the evaluation focuses on the reliability of the equipment, understandability and acceptability to passengers, legal issues, violation rates and the general workability of SSFC in a U.S. transit environment. Cost savings compared to conventional fare collection have been estimated, as were operational advantages.

The evaluation relied on records kept by MTDB and San Diego Trolley, Inc. (SDTI) of operations, maintenance, expenditures, operating reliability, enforcement, and the history of decisions leading to the designs and procedures in use. These records were supplemented by interviews with staff of MTDB and SDTI, which operates the Trolley under contract to MTDB. MTDB also conducted an on-board survey and a study of boarding times under its grant. A study of boarding times on a light rail system in Boston, with conventional fare collection, was undertaken for comparison purposes.

1.3 SYSTEM DESCRIPTION

The San Diego Trolley consists of a 16-mile light rail line running from downtown San Diego south to the Mexican border, as shown in Figure 1-1. A programmed 16-mile extension to the

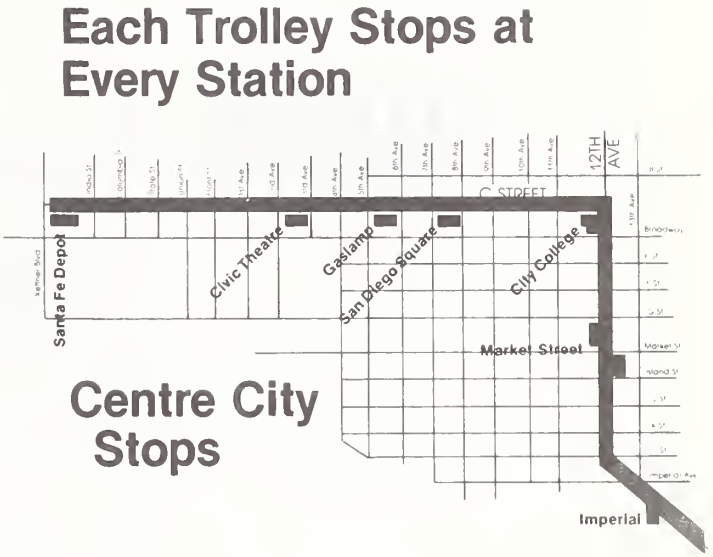


FIGURE 1-1. ROUTE MAP

east will soon go into final engineering. An additional line to the north is in the planning stage. The "San Diego Trolley Project Summary" reproduced in Figure 1-2, summarizes important data about the system.

The fare collection system operates without barriers, fare paid areas, or collection of fares by drivers or other transit personnel. Each passenger is required to have one of five valid proof of payment instruments while riding the trolley and to show it on demand to any of the uniformed inspectors who conduct spot checks on a regular basis. The five instruments and associated fares are described in Figure 1-3.

The use of bus transfers and monthly passes is much like other systems, except that drivers do not check them as a passenger boards. The single-ride tickets, the 10-ride

SAN DIEGO TROLLEY PROJECT
Summary

ROUTE CHARACTERISTICS

Limits	From Santa Fe Depot area in downtown San Diego, via C Street/12th Avenue and San Diego and Arizona Eastern Railway to San Ysidro at the International Border with Mexico; total length = 15.9 miles (25.6 km).
Railway Right-of-Way	14.2 miles (22.9 km) used for trolley operation in joint use with freight service, at-grade, initially single track operation with passing tracks. Phase II now under construction to double track the line.
Centre City	In downtown area, trolleys at-grade, exclusive path within city streets, for 1.7 miles (2.7 km) double track. A portion of C Street ultimately planned as a transit pedestrian way.
Metropolitan Transit System	Trolley line will be one route in overall system, time-coordinated at transfer points.

OPERATING PLAN

Frequency	7 days a week ..... 20-minute headways
Hours of Service	5:30 a.m. - 8:30 p.m.
Freight Movements	Freight service at night.
Trolley Vehicles	Electrically-propelled articulated vehicles, wheelchair accessible; in trains of two cars; fleet of 14 Siemens/DuWag cars in stock, 10 additional vehicles now on order.
Average Speed	9 mph (14.5 km/hr) ..... Centre City 30 mph (48.0 km/hr) ..... Railway portion of right-of-way
Maximum Speed	50 mph (80.0 km/hr)

ACCESS

Stops	C Street ..... 4 stops 12th Avenue ..... 3 stops Railway portion ..... 11 stops
Stations	10 standard stations along railway portion of route, plus one at International Border; low-level platforms with shelters.
Parking	2,000 parking spaces distributed among 6 of the 11 suburban stations along the railway portion of route.
Fare Collection System	Self-service, barrier-free, ticket inspection by roving inspectors.
Bus	Bus connections at all stations; National City 24th Street, Chula Vista H Street, Iris and downtown stops are major transfer terminals.
Bicycle	Racks and/or lockers provided at each suburban station.

FINANCIAL & CONSTRUCTION PROGRAMS

Costs	Total Phase I Project Development Cost (Including Interest Payback) ..... $86 million Total Includes: Railway Right-of-Way (108 miles) ..... $18.1 million Vehicles ..... $11.4 million Phase II Project Cost ..... $35 million Additional Vehicle Cost ..... $9.5 million
Resources	MTDB's state gas tax set aside for guideway (rail transit) development . 87.5% Transportation Development Act (TDA) monies (resulting from 1/4% state sales tax proceeds) 12.5%
Development	Engineering Initiated ..... January, 1979 Service Opening ..... July 26, 1981

TROLLEY OPERATIONS

Patronage	Initial Six Months ..... 11,000 - 14,000 average daily trips
Bus-Trolley Coordination	Existing bus routes reorganized in South Bay Corridor to avoid duplication and to feed trolley system; monthly Ready Pass good on trolley and bus systems; transfers are honored.
Farebox Recovery	82% for initial six months
Schedule Performance	98% on-time

FIGURE 1-2. SAN DIEGO TROLLEY PROJECT SUMMARY

Paying your fare

You must pay your fare *before* you board the Trolley. You can do this five ways.

1. **Single-ride Ticket.** Purchase from the ticket machine located at every Trolley station. Ticket good for two hours in one direction and serves as a free transfer to bus. Ticket machines require exact change in coins. Do not purchase return ticket at this time.
2. **Ready 10 ten-ride ticket.** Good for 10 one-way rides. No expiration date. If you begin your trip on the Trolley, you must validate your Ready 10 ticket at the left side of the ticket machine before you board the Trolley. Once validated, your Ready 10 ticket is good for two hours in the same direction. You may share your Ready 10 with friends by revalidating for each person. The Ready 10 serves as a transfer to a bus if necessary to complete your trip.
3. **Round-trip ticket.** Currently available at the Santa Fe Depot Stop and other selected outlets. Call 231-1466 for specific locations. Ticket needs to be validated in the ticket machine and is good for two hours of travel in the same direction.
4. **Bus transfer.** Ask bus driver for a transfer, good for 1½ hours. If you plan to travel from bus-to-Trolley-to-bus, alert the bus driver at this time. An upgrade ticket from the ticket machine at the Trolley station is needed if you paid LOCAL or URBAN bus fare.
5. **Ready Passes.** Monthly passes valid on Trolley and all San Diego and South Bay buses.

Fares

(Machines require exact change, Susan B. Anthony dollars accepted. No bills.)

One-way fare	$1.00
One-way elderly* & handicapped fare	.40
Reduced Centre City fare**	.25
"Ready 10"—ten-trip ticket	8.50
Monthly Ready Pass	36.00
Monthly elderly & handicapped Ready Pass	18.00
Transfer charge from LOCAL or URBAN bus services to Trolley	.20
Transfer charge from METRO (Express) bus services	FREE
Transfer charge for elderly* & handicapped	FREE
Children under 7	FREE

*Elderly—60 years and older
**Valid for one-way ride along C Street and 12th Avenue
Do not buy return ticket or validate Ready 10 until ready to return.

Always have proof of payment handy. From time to time you will be asked by an inspector to show proof that you paid for your ride. You must show proof of payment when asked. That's the law. IF YOU RIDE WITHOUT PAYING, you will be cited.

FIGURE 1-3. FARE PAYMENT METHODS

FIGURE 1-4. STANDARD STATION DESIGN OUTSIDE OF DOWNTOWN

"Ready 10" tickets, and the "Ready 2" round-trip tickets require use of the ticket machines which are located at every stop. Examples of a single-ride ticket and a Ready 10 ticket are shown in Figure 1-5. Six stops have one ticket machine and 12 have multiple machines. The machines vend single-ride tickets, coded with the date, time, machine number, and fare type paid. (The ticket in Figure 1-5 was vended from machine 59 at 10:06 AM on the 6th day of 1982.) The ticket machines also have a slot which patrons can use to validate their Ready 10 and Ready 2 tickets. Each single-ride ticket or multi-ride validation is good for two hours from time of issue in one direction only.

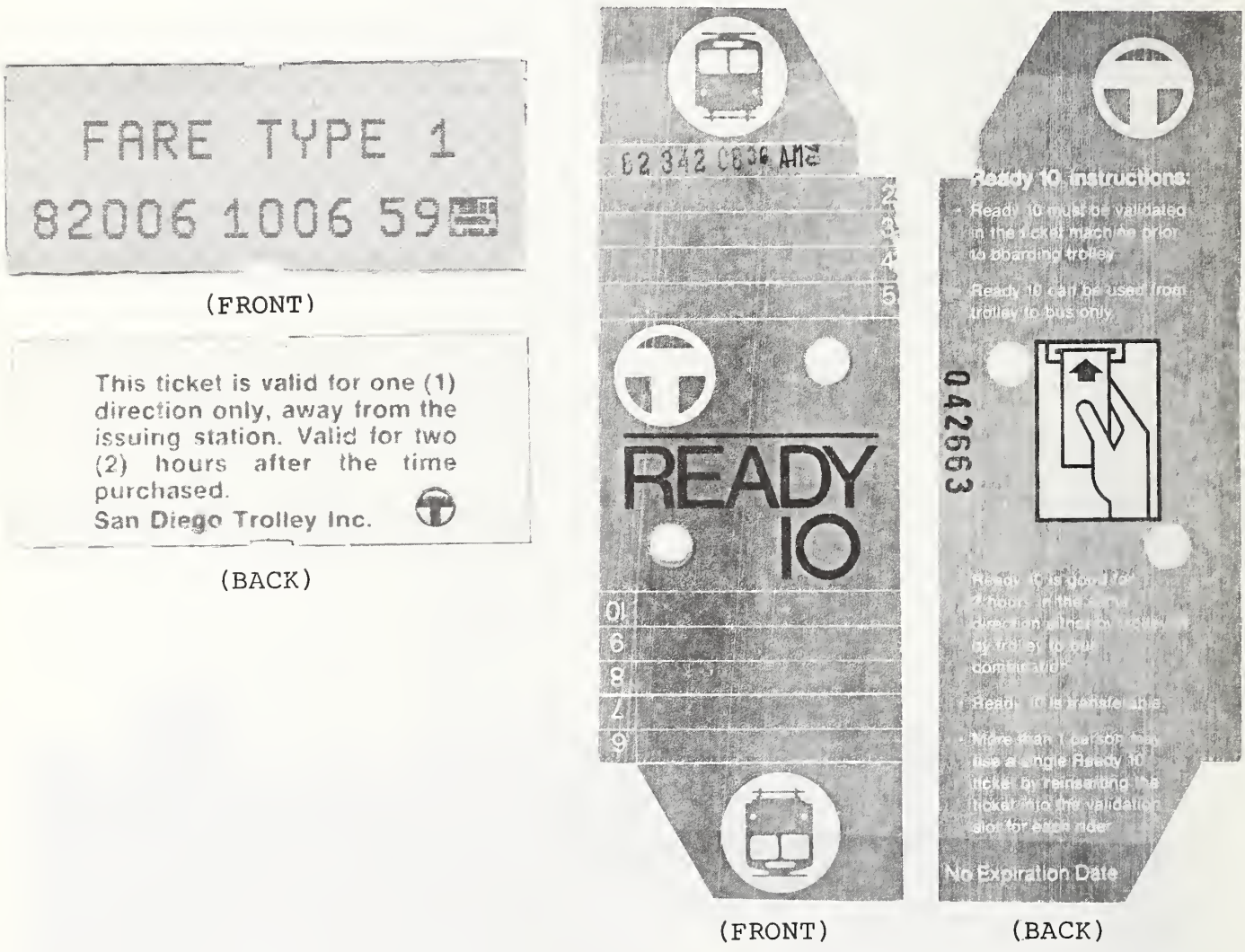


FIGURE 1-5. TICKETS VENDED AND VALIDATED BY MACHINES

The Trolley carries an average of 11,000 passenger trips daily, of which 60% are made using single-ride tickets, 13% with validated multi-ride tickets, 11% with monthly passes, and 16% with transfers. Data from 1981 and 1982 indicate heavier ridership in the summer than other times of the year. Travel to and from Mexico, both for work and other purposes such as shopping or recreation, appears to be a major component of ridership, since the border station accounts for 28% of all ticket sales and validations. In the on-board survey conducted in August 1982, 26% of weekday respondents and 37% of weekend respondents described themselves as "visitors or tourists." Several major military installations are important trip generators, and 15% of all survey respondents described themselves as "members of the armed forces." Other notable statistics are summarized in the following table:

	# of Weekday Respondents	# of Weekend Respondents
Making work or school trips	41	9
Ride more than once a week	57	30
Male	57	58
Annual household income $20,000 or more	42	48
Citizen of Mexico	10	7

The influence of tourists on the statistics would be much less during the non-summer months.

1.4 SETTING[1]

The San Diego Trolley serves the southwestern portion of San Diego county, running between downtown San Diego and the

[1]All data are from the 1981 Statistical Abstract of the United States or the National Weather Service Climate Summary for San Diego.

community of San Ysidro, adjacent to the U.S./Mexican border. San Ysidro is part of the City of San Diego, connected to the major part of the City by a narrow strip transversing San Diego Bay. Between downtown and San Ysidro the Trolley passes through the cities of National City and Chula Vista. Because the Trolley operates, for the most part, over railroad rights of way, it mainly skirts major residential, retail or office developments, with the exception of downtown San Diego and the border area. It does provide direct access to several major employers and military installations located between the railroad and San Diego Bay.

The San Diego metropolitan area, located in the southwestern corner of California, has a 1980 population of about 1.9 million people. It is the third largest metropolitan area in California. Nationally, it is similar in size to Cleveland, Atlanta, and Denver. The City of San Diego includes a larger percentage of the metropolitan area than the major cities of many SMSA's, making it the second largest in California and the eighth largest in the United States. San Diego County includes areas of very sparse development; the City itself had a 1970 density of 2,199 persons per square mile, and is one of the least dense major cities in the country or in California.

The San Diego region is one of the most rapidly growing ones in the United States. Its 1970-80 population growth of 37% places it in the same league with many other sunbelt cities. The military (primarily the Navy) and tourism are noticeably prominent components of the economy.

The coastal part of San Diego, including the area served by the Trolley, enjoys a mild climate. The average July high temperature is 75°F, the average January low temperature is 46°F. The climate is dry, with 9.5 inches of average annual rainfall, mostly confined to the months of November through April.

1.5 ORGANIZATIONAL ROLES

The roles and responsibilities of the organizations involved in the evaluation are described in the following paragraphs.

SMD. Sponsor for the evaluation. Defined overall goals, funded evaluation grant to MTDB, and sponsored evaluation through TSC.

Transportation Systems Center (TSC). Responsible for project evaluation under sponsorship of UMTA. Defined evaluation scope, issues and general methodology. Reviews and publishes evaluation reports.

Crain & Associates, Inc. (C&A). Evaluation contractor to TSC. Received task orders to design and carry out the evaluation. Specified and designed data collections and prepared evaluation report.

MTDB. Acts as metropolitan planning organization for public transportation in the City of San Diego and seven cities to the south. Administers state transit assistance for all local transit in its area of jurisdiction and participates in setting transit fares. Has responsibility to plan, build and operate rail transit in the San Diego metropolitan area. Contracts for operation of the trolley and carries out the enforcement component of SSFC. Applied for and received SMD grant for evaluation of SSFC. Responsible for data collection for the evaluation.

San Diego Trolley, Inc. (SDTI). A non-profit corporation, owned entirely by MTDB, operates and maintains the Trolley. Provided data on maintenance, costs and operations for the evaluation.

San Diego Association of Governments (SANDAG). The general metropolitan planning organization for the San Diego region. Acts as data collection contractor for all transit operators in the San Diego area. Conducted surveys and major data collections for this evaluation.

FIGURE 1-6. NATIONAL CITY 24th STREET STATION

FIGURE 1-7. DOWNTOWN TROLLEY STOP

FIGURE 1-8. BUYING TICKETS AT THE BORDER

2. EQUIPMENT

2.1 DESCRIPTION

The major equipment item required for SSFC as implemented in San Diego is a machine which vends single-ride tickets and validates multi-ride tickets. Each of the 18 stops on the trolley line has one or more ticket machines to dispense single-ride tickets and validate multi-ride tickets. Twelve of the stops have multiple machines, bringing the total to 33 machines. The machines were purchased from Autelca AG, of Berne, Switzerland, which designates them as Type BE-20 Automatic Ticket Distributors. They have been supplied in slightly different forms to European transit properties. The San Diego Trolley is the first transit system in the U.S. to use the machines.

2.1.1 External

Figure 2-1 shows the exterior of a ticket machine. A passenger must first press one of five buttons indicating which of five ticket types is to be purchased:

1. Regular full fare ticket--$1.00
2. An "upgrade" ticket to be used in combination with a non-express bus transfer--$.20
3. Senior ticket--$.40
4. Disabled ticket--$.40
5. Centre City ticket--$.25

A sixth button is available for future expansion and has no use at present. The display at the top right then shows the amount to be paid, which must be deposited using exact change. As coins are deposited the display counts down, showing the amount owed. The machines accept nickels, dimes, quarters, half dollars and Susan B. Anthony dollar coins, but do not accept dollar bills.

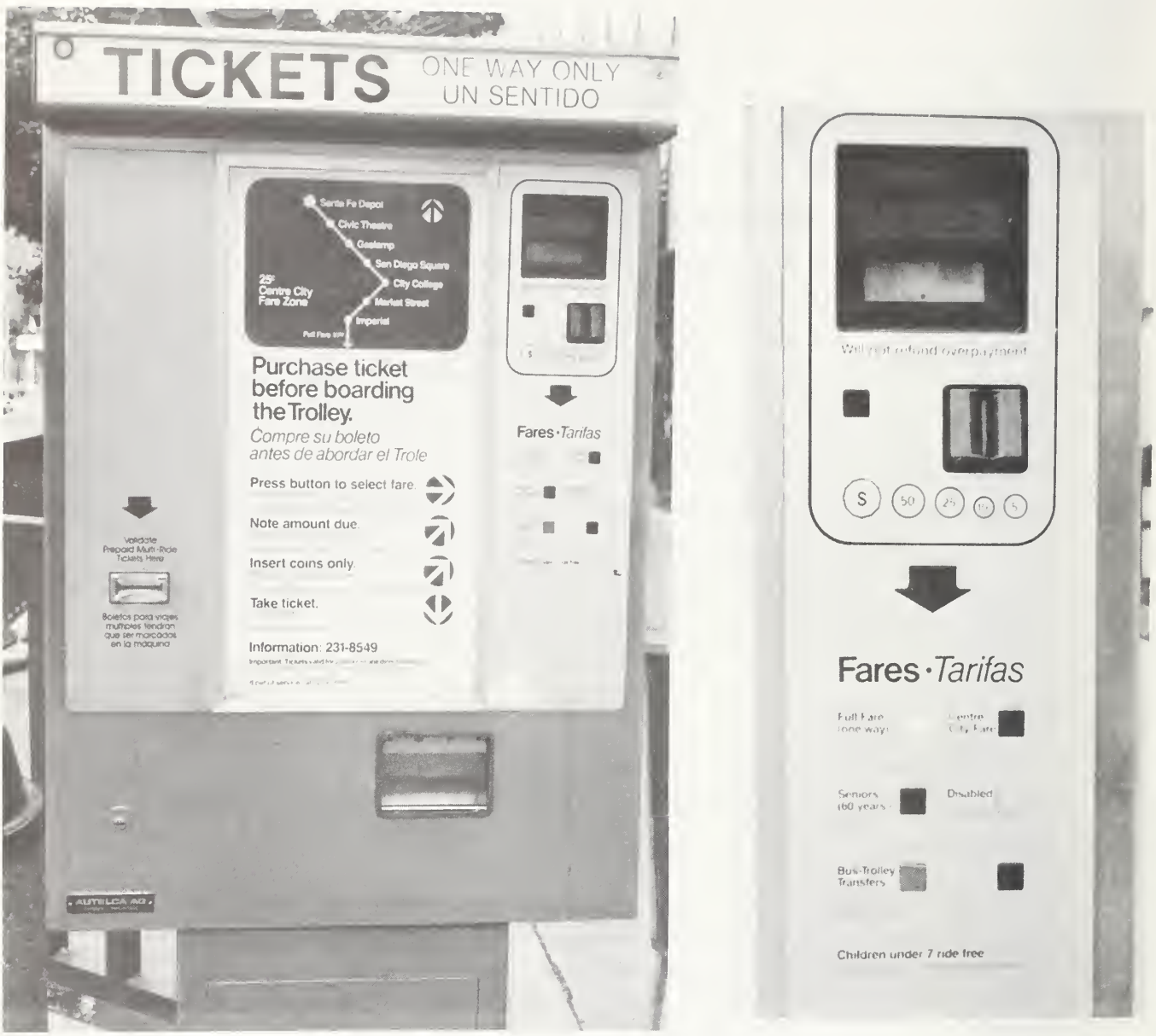


FIGURE 2-1. EXTERIOR OF A TICKET MACHINE

The ticket is vended through the tray at the bottom of the machine. On the left hand side of the machine is a slot for validating multi-ride tickets.

The machines are mounted on pedestals which include the cash box. Access to the ticket machine and the cash box are through separate doors, each requiring a different key. A third door, at the bottom of the pedestal, opened by a third key, provides access to the power supply and a "silent alarm."

2.1.2 Internal

The ticket machine has 11 major components or "modules". They are:

1. Electronic central unit--The electronic controls and "brains" of the machine. Four printed circuit boards control the fare display, the printer, program storage and data collection.

2. Needleprinter--Mechanically cuts and prints tickets with type, date, time and location codes.

3. Coin verifier--Identifies electrical, magnetic and mechanical characteristics of the coins so that pennies, slugs and foreign money are rejected.

4. Foreign body rejector--Automatically seals coin slot and protects against bent coins.

5. Power supply--Contains an AC to DC converter.

6. Cash box--Coins, when accepted by the verifier, drop into the base of the machine where the cash box is contained.

7. Price display--Four digit LCD display of ticket price and balance due.

8. Service keyboard and display--Internal input/output unit used to program electronic central unit and display error codes in case of machine failure.

9. Alarm--Sounds when door is opened improperly and sets off silent alarm to alert central control. The silent alarm signals central control via a direct-dial telephone line in the event of a break in, power loss, or a machine going out of service. A decoder at central control distinguishes these alarms and announces them visually, audibly and by printout.

10. Heating unit--Maintains temperature above 10°C (50°F).

11. Validator unit--A completely separate mechanical unit with its own power supply and electronic controls. Cuts a diagonal slice on an inserted Ready 10 ticket and prints date, time and location codes.

Each of the modules, except for the independent validator unit, is linked electronically to the electronic central unit. The central unit routinely records transactions, coin intake, and money errors.* These statistics are used to verify cash box receipts and to estimate ridership figures for each station. The central unit will also attempt to self-diagnose any machine failures. Any failures that it is able to detect are displayed on the service display using a two-digit error code. Errors are classified as technical (20-28, 40-59) and administrative (01-10). Administrative errors are problems such as "no paper", "cash box full", or "coin jam" that require action but are not defects in the ticket machine. Technical errors usually are mechanical or electronic malfunctions such as "clock defective", "foreign matter rejection motor jammed", or "cutter blocked". The machine is not able to correctly self-diagnose all of its problems. Many printer failures reported as technical errors are problems such as "improperly fed-in paper" which are not actually machine defects. Also, some errors cannot be detected by the electronic central unit. Failures in the coin verifier and printer can occur without being diagnosed. Validator problems are never reported by the machine because it is a completely separate unit without self-diagnosing capabilities.

2.2 PROCUREMENT

2.2.1 Specification

Procurement of the ticket machines was carried out by MTDB's primary contractor on the Trolley project, Bechtel, Inc. A

*An example of a money error would be if a patron inserts money into a fare machine, but the machine goes out of service for some reason without dispensing a fare.

specification for 28 machines was issued for bids on July 30, 1979. The specification was based on research into the available equipment, carried out by Bechtel and Tom Parkinson Transport Consulting of Vancouver, Canada. Among the more interesting requirements of the specification were that the machines:

1. Operate without protection from the weather
2. Be "standard production models" with 50 machine years of service in public transport
3. Accommodate six fare values
4. Vend a minimum of 4,000 tickets of at least 3 cm width without paper replacement
5. Print tickets with the date, time, machine number, origin station, and destination zone*
6. Be able to validate multi-ride tickets.

The technical specification allowed considerable flexibility within the confines of such general functional requirements. Bidders were asked to price numerous options, including:

a. Change making
b. Illumination
c. Digital displays of the fare selected and amount of coins deposited
d. Local and remote problem indicators (e.g., out of service, out of change, out of paper)
e. Back-up battery power for clock and/or vendomat
f. A method to cancel a multi-ride ticket for different fare tariffs
g. Audit data on money accepted and tickets vended
h. Stand-alone validator in place of or in addition to built-in unit
i. Extra space for public information

*The printing of a destination zone was dropped in favor of printing the fare type, at the suggestion of Autelca.

j. Display of clock time on the digital coin counter when machine is not in use for ticket vending

k. Ability to vend tickets with overpayment

l. Ability to accept Mexican coins

m. Deletion of ability to accept Susan B. Anthony dollars

n. A coin return for cancelled transactions.

2.2.2 Bids

Four bids were received, including one from a domestic supplier. Autelca Ltd., of Gumligen/Berne, Switzerland was the apparent low bidder by a wide margin. MTDB staff felt that Autelca had a particularly well-designed, reliable unit, and a strong interest in protecting a reputation for quality which would ensure good service to MTDB. Therefore they entered into negotiations with the low bidder in late October 1979. Autelca's basic bid included as standard equipment most of the optional items listed above. Change making was considered a standard feature by Autelca, but could be deleted at a savings of about $2,900 per machine. Machine illumination could be deleted for about $400 per machine. Two items which were not available were: (f) multiple-zone cancellations and (i) extra space for information. Battery back-up power (e) was standard for the clock but not available for the whole machine. Mexican coins (l) could be accepted instead of U.S. coinage on particular machines, but not in combination with U.S. coins. Not accepting dollar coins would not produce any price reduction.

2.2.3 Purchase Orders

A purchase order for a total or $424,729 was completed by both parties on December 3, 1979. For this price Autelca promised to ship 28 fare collection machines by October 31, 1980. The price

included the machines, 28 exchange coin vaults, pedestals, freight and custom duties, but not 6% California sales tax (paid separately by MTDB). As a result of the negotiations which had already taken place, a purchase order revision was carried out soon after the original purchase order. The revision, in the amount of $80,915, included:

Stainless steel cases on all machines	$20,440
Sirens	7,000
Illumination units	9,520
Spare parts	32,528
Consumables (ribbons, ticket stock)	7,568
Customs	3,859
	$80,915

In addition, Autelca agreed to supply another approximately $16,000 in spare parts on consignment for one year. These are parts which MTDB held in its parts inventory and paid for when used. Three more purchase order revisions added $62,327 to the total purchase price. They covered extra coin vaults, more spare parts, test equipment, inflation and installation costs not covered by the original purchase order. In all, MTDB paid $567,971 for 28 fare collection machines and associated equipment, parts and services.

Shortly before service began, MTDB concluded that additional ticket machines would be desirable. A fifth purchase order revision was issued on April 20, 1981 for six additional machines at a price of $114,275.

2.3 RELIABILITY

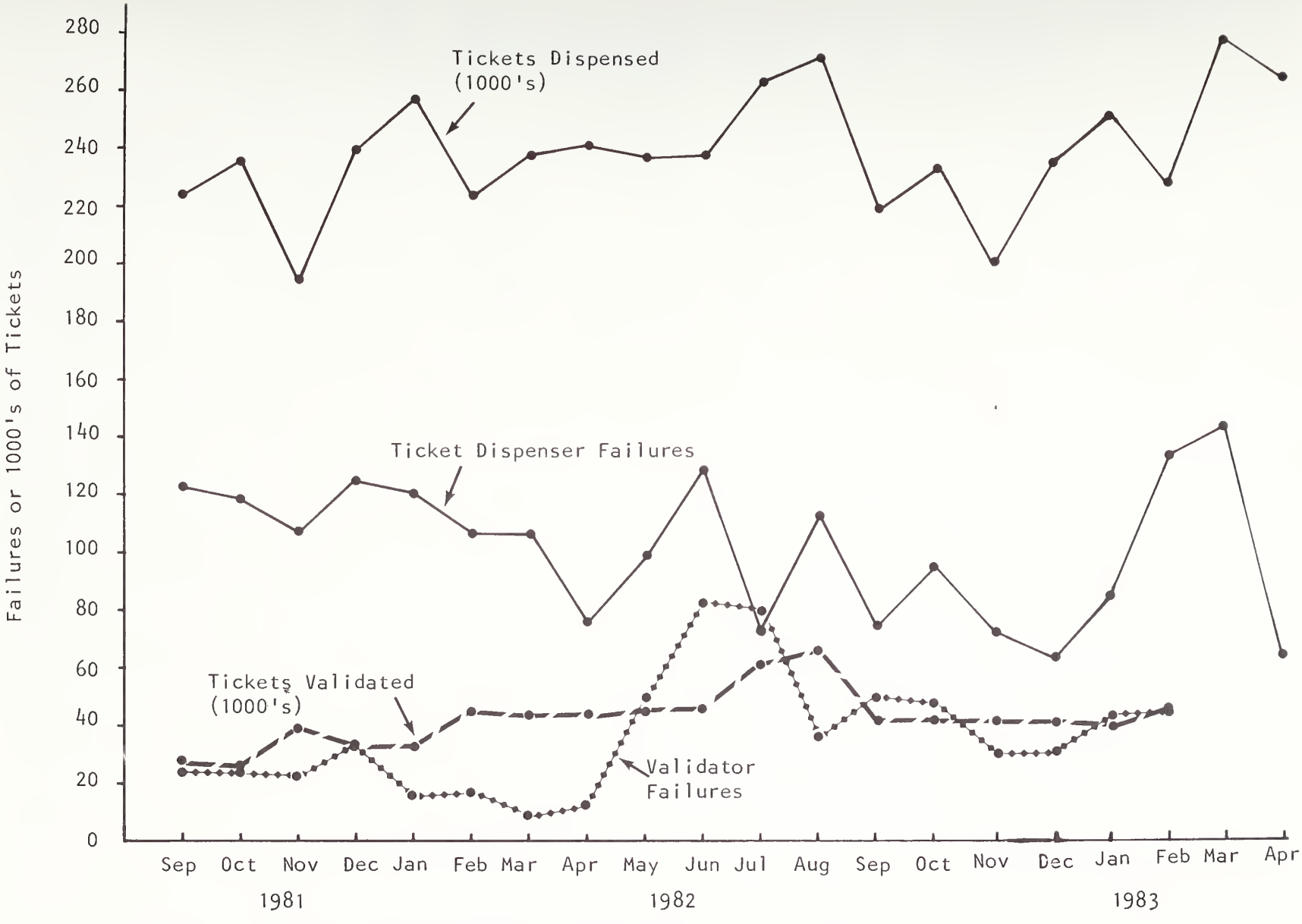
Staff of MTDB and SDTI are pleased with the reliability of the ticket machines. They feel that the supplier, Autelca AG, has been very cooperative and has responded in a very timely fashion to help with those problems which have occurred. Of course some problems do occur, and this section documents them for the benefit of operators planning for or considering SSFC. In reading this material, one should keep in mind that it is mostly

based on the first year and a half of operations. Even toward the end of this period, staff were still learning about the ticket machines. In the future many of the problems described here may cease to be a concern. In addition, the reader should note that many of the problems discussed are non-mechanical. Examples are failures caused by defective paper stock and initially emptying the cash boxes too infrequently.

2.3.1 Performance History

Figure 2-2 graphs the total reported ticket dispenser and validator failures for 14 months of trolley operation (excluding false reports) as well as the total number of tickets dispensed and validated for each month. During the first month of operations, not shown in Figure 2-2, there were 265 ticket dispenser failures, more than twice the number in any subsequent month. Most of these early problems were solved after the first month as the maintenance staff learned how to adjust the machine and anticipate problems. For example, the two major problems during the first month were coin jams, reduced by adjusting the coin verifier, and machines running out of ticket stock, solved by increasing the frequency of paper replenishment. Machines running out of ticket stock is an example of a type of problem which, although counted as a failure because it does result in a machine being out of service, is not, strictly speaking, a failure of the machine itself. The use of the machines was also quite high during the first month of operation, probably because of heavy tourist usage, since a similar rise in ticket machine usage occurred the following summer. Machine failures appear to have tended to fluctuate more than ticket machine use.

After the first month of operation, machine failures steadily decreased to a low in April 1982. The only changes made until that time were minor mechanical adjustments. In April, the manufacturer supplied San Diego with new software programs to alleviate problems in the coin verifier and to prevent the cash boxes from being overfilled.



Source: SDTI Monthly Failure Statistics and MTDB Monthly Summaries of Vendomat Transactions

FIGURE 2-2. MACHINE USAGE AND FAILURES

Around this same time, two of the machines were broken into and the cash boxes removed. The cash box is accessed via a door on the pedestal. This door has a latch which is not flush with the door face, allowing someone to pry the latch open. A metal doughnut was installed around the latch to prevent insertion of a prying tool. The problem has not recurred.

The changes made in April helped to reduce coin verifier and cash box problems but the reduction in these problems was counterbalanced by a major increase in ticket paper and validator problems in May and June, causing an increase in the total number of failures. Ticket paper problems consisted of an increased frequency of machines running out of ticket stock (18 cases in May and 25 in June), and a batch of ticket stock in which a hole, which tells the printer where to cut each ticket, was occasionally not punched (33 cases in May and 41 in June). Both problems were solved in July 1982 when paper from a new supplier was put into use.

The increase in validator problem was thought to be due to normal wear and tear on the validator printer, especially the motors. The most frequent problem consisted of printing the wrong date or time on multi-ride tickets because the motor did not have enough power to ensure that the printing wheels were rotated. During the summer of 1982 SDTI added a filter to the printer power supply, which eliminated a tendency for the pulse to the printer to vary significantly for the correct voltage. Beginning at about the same time, new print heads were installed in all the validators. The new print heads were supplied by Autelca at no cost after they discovered that fine metal dust had lodged into the mechanism during manufacturing. The changes substantially reduced the rate of validator problems, although not back to earlier low levels. Autelca later determined that some problems resulted from using the wrong type of brushes in the print wheel motors, and agreed to replace the motors.

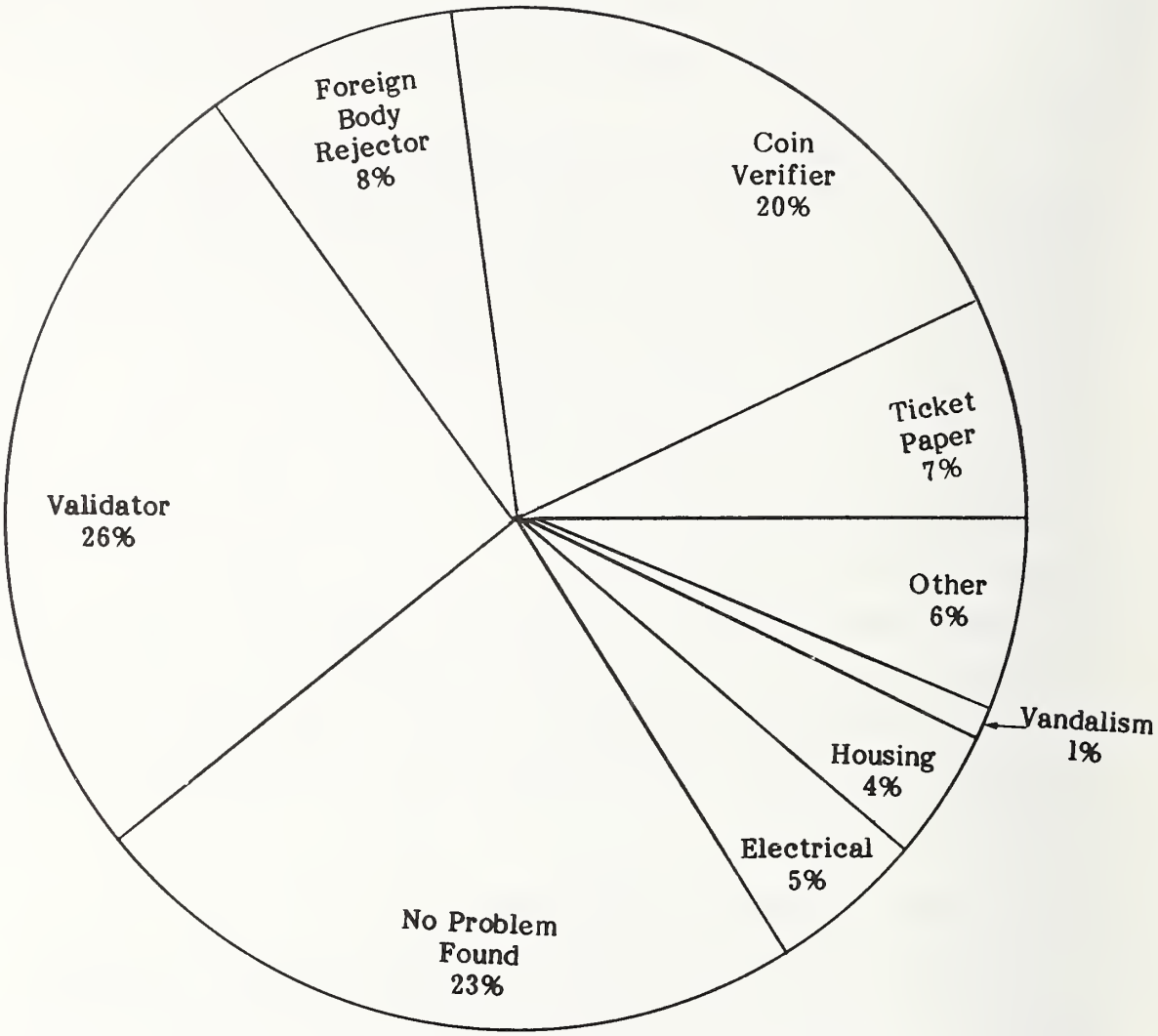
During the summer of 1982, MTDB purchased four dollar bill changing machines at a cost of $9,900 (plus tax), which were installed at four of the busiest stations. In September and October

1982, these four machines had a total of 131 reported failures. Many of the failures were attributed to the bill stacker. The bill stacker has been removed and reported failures have fallen considerably. However, the dollar bills have to be stacked manually.

The increase in failures in February and March of 1983 was a direct result of wet weather. Wet weather caused two types of problems. First, patrons inserting wet and dirty coins into fare machines caused the coin verifier surface to develop a film and, in turn, lose sensitivity. Autelca tested a water draining channel which was installed in all the fare machines. This allows any water entering the machine through the open coin slot to drain away from the interior mechanism. Wet coins, however, will continue to pose a problem. Second, when maintenance personnel opened fare machines for repair or inspection, driving rain sometimes reached the internal components, causing paper to swell up and short out electric signals. To reduce this problem, maintenance personnel will use large umbrellas or plastic sheets to cover themselves and the fare machines during driving rainstorms.

2.3.2 Types of Machine Failures

Figure 2-3 is a pie chart showing the major problems occurring in the ten months from July 1982 to April 1983. In that period, the validator accounted for more problems (26%) than any other module. The coin verifier and foreign body rejector together accounted for 28% of the problems, reflecting the numerous failures due to wet weather in the period summarized. The 8% of problems related to ticket paper is much reduced from the 25% of problems due to the same cause in the first half of 1982. The distribution of problems shown here may not reliably predict experience in the long run, since the distribution has varied considerably over time, with one type of problem predominating for a while, and then another type of problem. Detailed summaries of machine failures are presented in Table 2-1.



Source: Wayside trouble reports for July 1982-April 1983 and SDTI monthly summaries.

FIGURE 2-3. DISTRIBUTION OF REPORTED TICKET MACHINE PROBLEMS.

TABLE 2-1. DESCRIPTION OF FAILURES AND TYPICAL REPAIR ACTIONS

Failure Type	Description	Typical Action	Failure Type % of Total
Paper problems			
Needleprinter unit	-Paper blockage -Paper inserted wrong -Bad paper (no holes)	-Clear blockage -Reinsert paper -Replace paper supply	6%
Paper out	-Paper supply out	-Replace paper supply	1%
Coin related			
Verifier	-Coin jam -Not accepting coins	-Clear coins -Adjust sensors	20%
Foreign body rejector	-Coin jam -Broken coin slot	-Clear coins -Replace coin slot	8%
Validator	-Printed date wrong	-Recycle motor, reset, replace if necessary	26%
	-Jammed by regular fare ticket	-Clear blockage	
No Problems Found	-Trolley passenger reports machine is not taking money, validating tickets or giving tickets	-Check ticket dispensing and validation	23%
Electrical	-Internal electronic failure -Power off or intermittent	-Replace defective part -Check power connections	5%
Housing	-Ticket tray, coin slot broken	-Replace or adjust	4%
Vandalism	-Coin slots blocked by bubble gum -Housing tampered with	-Clear blockage, clean internal parts -Replace housing part	1%
Other	-Cash box full -Not reported on troublesheet or not easily discernable	-Call to have cash box replaced -Various actions	6%

Source: Wayside Trouble Reports and SDTI Monthly Failure Summaries

Paper Problems

Paper problems can be divided into technical problems with the needleprinter unit or an administrative error: exhaustion of the paper supply. Needleprinter errors are most often caused by paper blockage due to improper insertion or misalignment of the paper, or defective paper. Defective paper was a problem because it was slightly too heavy and would swell up in high humidity, jamming the machine. Also, there was a quality control problem with the holes, used by a sensor, not being punched properly or at all. Without these holes, the printer could not determine where to cut the ticket. Paper-out problems were common initially before the service personnel gained a feel for how often machines needed to be replenished with new paper stock. It is now a very minor problem which occurs two or three times a month. When a small amount of ticket stock remains in a machine, there is now no way to add additional paper. Rather a new supply must be put in place, which the service personnel are reluctant to do too soon, as the leftover stock will be wasted. In the future, a method may be devised to link additional paper to the existing supply.

Coin-Related Problems

Coin-related problems can be isolated in two major components of the coin mechanisms: the verifier which checks the coin for authenticity, and the foreign body rejector which helps to prevent coin jams. The verifier is a very sensitive piece of equipment and is able to sense weight, size, embossing depth and alloy content. Because of this sensitivity, the verifier has not caused any problems by accepting slugs or foreign money (Canadian or Mexican). However, the machine will often reject U.S. dimes because their size, weight and alloy content are sometimes similar to those of Canadian dimes. The problem is not generally severe and can be adjusted in the field. Bent or multilated coins or material other than coins can cause a coin jam, as can several coins fed in too quickly. The foreign body rejector is designed

to clear these jams but sometimes is not successful; the machine then goes out of service. The general solution is to manually clear the coin jams or to clear the slots of non-coin material (tickets, bubble gum and the contents of a soft drink have been found in the past). Heavy rains and strong winds in the winter of 1983 brought problems either from rain blown into the coin slot or patrons inserting wet coins. A water draining channel has been installed in all the fare machines.

Validator Problems

The multi-ride ticket validator, as mentioned before, is a completely separate mechanical unit with its own counter and time clock. It is of a much less sophisticated design than the ticket dispenser having none of the latter's solid state electronics. The most commonly recurring problem is the misprinting of dates or time (see previous section); resetting the date and time and cycling the motor a few times clears the problem temporarily. Another problem is caused by a common misunderstanding by new users of the trolley. Some passengers will attempt to insert their single-ride trolley ticket into the validator and thereby jam it. A new multi-ride ticket was recently put into use, which is expected to reduce the incidence of validator jams.

False Reports

"False reports" are cases in which a reported problem could not be reproduced by SDTI's maintenance personnel. Much of this problem is simply due to newcomers' inexperience with the machine. Observing first-time ticket users, it is clear that many do not realize that they must push an appropriate fare button before they can insert coins. Sometimes a ticket user will not realize that a ticket is not being dispensed because a coin (often a dime) was not accepted by the machine. The display does indicate that there is an amount due; however, it is easy to not see or hear

that a coin has been returned. Reports from the passengers tend to be vague--"The machine at Sante Fe is not working"--so it is unclear which is the most common misunderstanding.

Vandalism

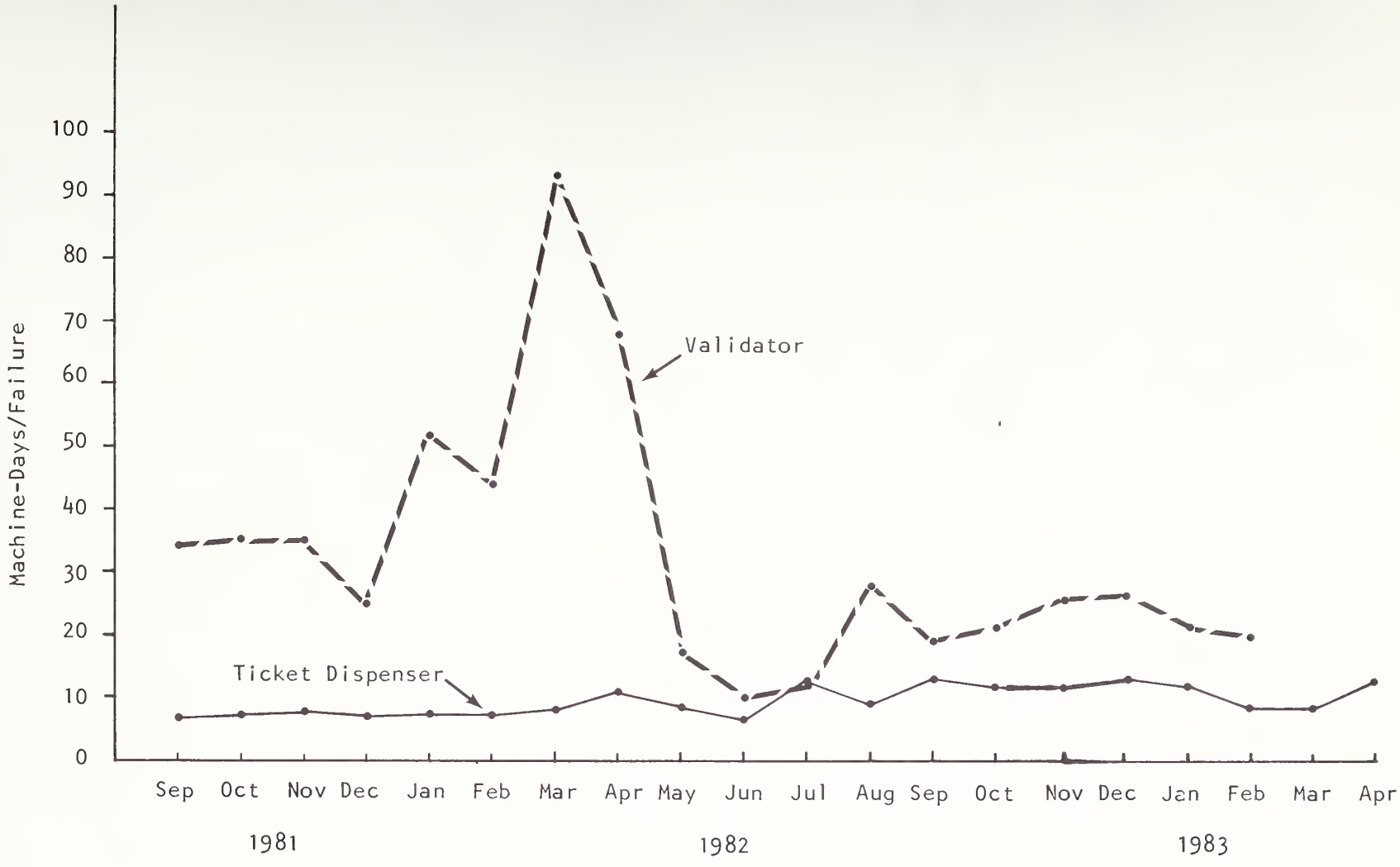
Vandalism, although rare, can be severe. One unit was severely damaged by someone with a blunt instrument. Liquids and gum stuck into the coin slot do not usually reach the electronic units but require major cleaning nonetheless. Very little in the housing is breakable. A few smashed display units have occurred but the rest of the case is tough stainless steel and relatively impervious to graffiti or scratches.

Other Problems

The remaining machine failures are fairly infrequent. The electronic parts, especially, seem to be working reliably. Temperature, humidity or precipitation problems, common with electronic units, have not surfaced in San Diego. Undoubtedly, this is partly due to the mild weather there. Road grit and dust do not seem to make their way into the unit, but some of the fare buttons seem to get sticky after a while and require cleaning about twice a year. Cash box problems, generally because of a filled cash box, essentially disappeared once twice-a-day pickups began after the first month of operation. In the heavy rains of early 1983, water was sometimes blown into the ticket tray. A hose was installed to drain water away from the tray.

2.3.3 Measures of Reliability

Three measures of reliability have been computed for the ticket dispensers and validators: mean time between failures, mean transactions between failures, and percent availability. Figure 2-4 shows mean time between failures, by month, for 20



Source: SDTI Monthly Failure Summaries

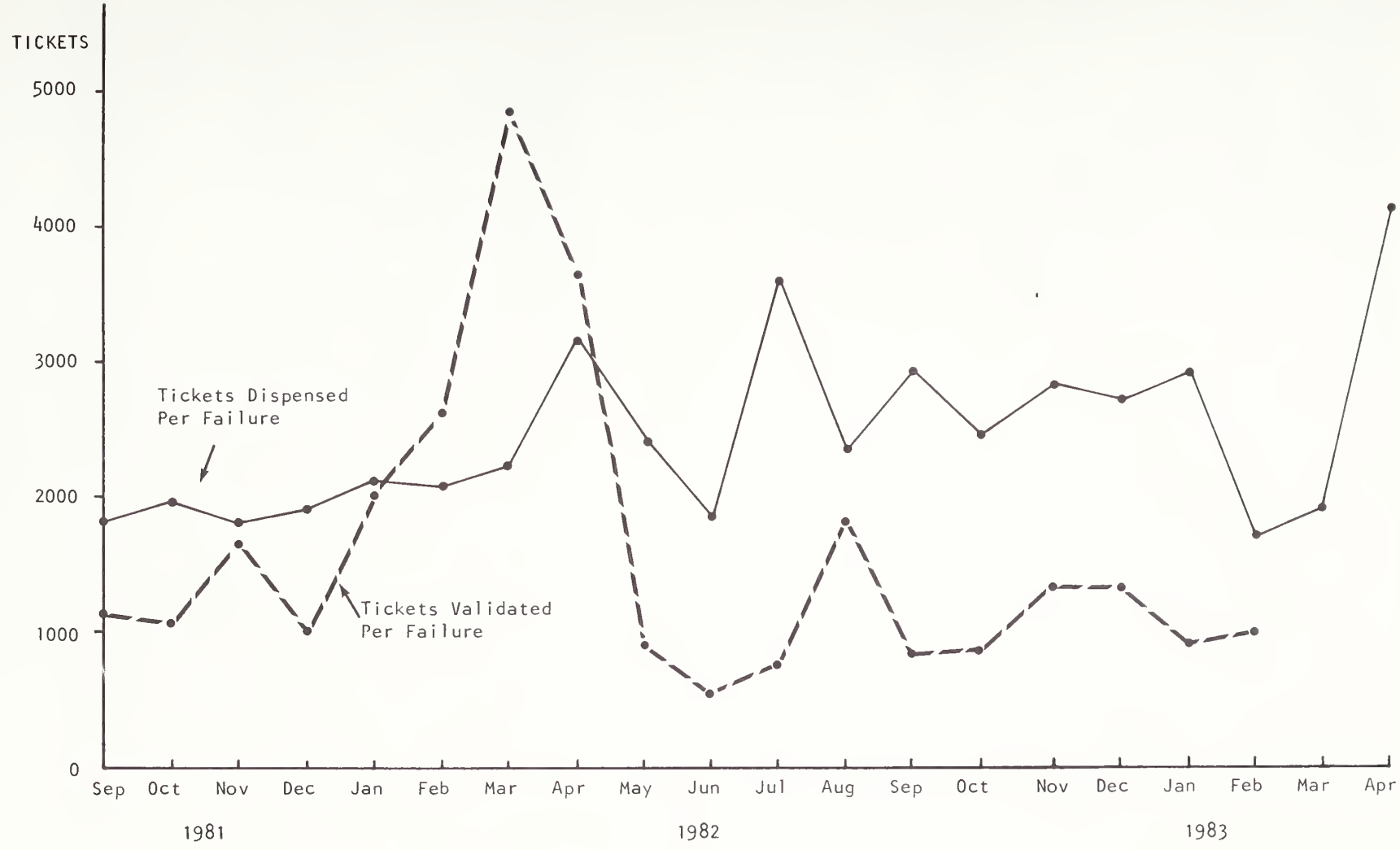
FIGURE 2-4. MACHINE DAYS BETWEEN FAILURES

months.* By this measure the validators were quite reliable up until the spring of 1982: the average unit failed less than once a month. After that the validators have had a lot of problems. The modifications made beginning in the summer of 1983 appear to have improved the validators' reliability. The ticket dispensers fail more frequently than the validators, largely due to heavier use, as shown below. Despite some setbacks, such as the rain-induced problems in February and March 1983, the general trend has been toward increasing reliability.

Mean transactions between failure over 20 months are graphed in Figure 2-5. By this measure the dispensers are seen to be generally more reliable than the validators, and improving. For the first six months shown, the dispensers averaged one failure per 1,958 tickets dispensed, compared to one failure per 2,594 tickets in the last six months. The validators' failure rate has fluctuated considerably. Initially, the typical failure rate was around 1,100 validations per failure. Following a few months of extremely reliable operation, the validators' typical performance has fallen to around 800 to 900 validations per failure.

To compute the percentage of time the average ticket dispenser or validator is available for use, it is necessary to combine the average time between failures and the average time between failure and repair. According to SDTI staff, many problems are fixed by the maintainer in the course of making routine checks of the machine, rather than in response to a trouble report. In such cases, the machine will be out of service for eight hours (half the Trolley's 16-hour service day) on the average, since every machine is checked at least once a day. Many failures are fixed more quickly, because they are reported either by patrons or the station attendants on duty at the Border and Santa Fe from 8 AM to 5 PM. In such cases about

*Data for the validators are missing after March 1983 because of a change in reporting methods.



Source: SDTI Monthly Failure Summaries and SANDAG Vendomat Program

FIGURE 2-5. TICKETS DISPENSED AND VALIDATED PER FAILURE

two hours will elapse between failure and repair. These two failure-to-repair intervals provide upper and lower bounds for estimates of percent availability.

The data in Figure 2-4 show failure intervals, over the last six months of data, of 24.7 machine-days per validator failure, and 11.8 machine-days per dispenser failure. Based on a 16-hour service day, these imply rates of 395 in-service hours between validator failures and 189 in-service hours between dispenser failures. The conservative estimates of availability, based on eight hours between failure and repair, are then 98% for the validators and 96% for the dispensers. More optimistic estimates, based on two hours between failure and repair, are 99% for both units. Since nine-tenths of all ticket purchases and validations are made at stations with two or more fare machines, patrons should almost always be able to find at least one working fare machine when they need to buy or validate a ticket.

2.4 MAINTENANCE

2.4.1 Training

Two persons from the SDTI Maintenance department were given in-depth factory training in Berne, Switzerland for five weeks on major servicing of the coin verifier, needleprinter cancellor and other modules. Training and lodging costs were paid by Autelca, traveling and living expenses were paid by SDTI. One of the trainees was a supervisor, the other an electro-mechanic (who, unfortunately, left SDTI not long afterward), both with good electronic and mechanical background. The training took place between mid-February to mid-March 1981.

2.4.2 Technical Assistance

A factory-trained company representative was required by contract to supervise and give technical assistance to the maintenance staff to install the original order of 28 machines at

various station locations and put them in service. Prior to installation, the machines were assembled and powered-up for shop burn for a period of four weeks. All functional tests and adjustments were made on these machines by the maintenance staff with the assistance of a factory representative. This was a major hands on, on-the-job training for SDTI maintenance staff, as well as the two factory trained staff members. A technical representative remained in San Diego for three to four weeks to help out with start-up problems.

After the departure of the factory representative, factory-trained staff members continued on-the-job and shop training for other maintainers on an ongoing basis. In mid-1982, Autelca sent their technician to San Diego again for two weeks of follow-up training and monitoring machine performance. This was very helpful to SDTI, since after months of operation the nature of the problems were different and a few modifications made needed to be evaluated.

While on-the-job training continues by the Maintenance Supervisor, periodic retraining by service representatives from Autelca is being considered.

2.4.3 Test Equipment and Spare Parts

Because of the time and cost involved in returning parts to Switzerland for repair, SDTI's philosophy has been to trouble-shoot and repair modules and boards to component level in-house. To facilitate detailed troubleshooting, a complete set of test programs and test equipment was acquired from Autelca. The initial cost for this equipment was $15,000. SDTI staff feel that this money was well invested. One spare machine was also acquired to be used as a test and demonstration machine in shop. It serves as a good training aid, as well as very effective test equipment.

Shortage of machine spare parts has not been experienced, but SDTI did experience a minor shortage in printer and cancellor

ribbons because of long lead time and unclear rate of usage. Appropriate stocking levels of wear parts and consumables, like ticket stock and ribbons, depend on total transactions which could not be reliably predicted at first. SDTI is seeking local sources which would save freight cost and reduce lead time, thereby lowering inventory levels and cost.

Based on SDTI experience, stocking level for electronics parts could be as low as 6% as they are quite reliable with few failures, but mechanical parts which are finely tuned and susceptible to wear and tear, should be stocked at a higher level. Since SDTI does most of its work in-house, a comparatively small inventory of larger assemblies and modules is kept. SDTI does stock smaller specialized parts.

The machines are maintained by assistant linemen in vans or trucks that are responsible for all the various components of the trolley system: ticket machines, tracks, grounds and overhead lines. During the entire day, one lineman is primarily responsible for fixing the machines and will spend at least 90% of his time responding to ticket machine problem calls or on routine maintenance. The linemen carry spare modules that are most frequently needed such as coin validators or printer motors. If the problem cannot be isolated in the field, the module is replaced and the part is brought to the electronic technician to troubleshoot. These more difficult problems take a few hours of shop time to repair. (The ticket machine itself is repaired much more quickly by installing a spare module). The technician also uses the opportunity to overhaul the module if it needs cleaning or adjustment.

Formal procedures for preventive maintenance are now being introduced, based on an Installation, Operating and Service Manual provided by Autelca and on SDTI's field experience. Whenever the maintenance crew in the field has time, they perform preventive maintenance according to the manual and additional, informal procedures which have been established verbally.

2.4.4 Time to Repair

Time to repair consists of travel time and time spent working at the ticket machine. Table 2-2 shows the average time recorded by the linemen for repairing various types of problems, not including travel time, during the month of May 1982. The average time for all types of problems is 16 minutes. The average reported time for validator problems was 24 minutes; for ticket dispenser problems it was 14 minutes.

The lineman spends much of his time traveling between stations; it is approximately 16 miles and 30 minutes by car from the city center to the southernmost station. No separate accounting of travel time is available, but it is possible to estimate the total

TABLE 2-2. TIME TO REPAIR BY FAILURE TYPE

Failure Type (Number of observations)	Average Time (Minutes)	Percent of Reported Failures
Paper problem		
Needleprinter (26)	17	6 %
Paper out (15)	15	1
Coin related		
Verifier (9)	20	20
Foreign body rejector (5)	19	8
Miscellaneous (4)		
Cash box		
Housing		
Electronics	12	10
Power supply		
Vandalism (4)	37	1
No problem found (8)	6	23
Other dispenser failures (7)	10	5
Validator failures (37)	24	26
ALL FAILURES	16	100%
ALL DISPENSER FAILURES	14	[illegible]%

Source: Wayside Trouble Reports for May 1982

time, including travel and repair time, which elapses between the time a problem is first reported to the maintenance crew and the time it is reported fixed. Figure 2-6 shows the average elapsed times, by station, based on the controller's log for May 1982, for all problem types. The southernmost station takes the longest to travel to and repair; stations near the Imperial stop, where the trolley maintenance facility is located, generally take the least amount of time. During the morning, the maintenance person will generally station himself near the southern stations while in the evening the maintenance person will be centered in the city core. The lineman will sometimes have a backlog of calls after the morning shift, so little of his time is left idle.

From the systemwide average of 40 minutes, shown in Figure 2-6, and the average on-site repair time of 16 minutes reported in Table 2-2, it is possible to infer that the average repair requires 24 minutes of travel time. This makes the total elapsed time to travel to and repair a problem, 48 minutes for validator problems and 38 minutes for ticket dispenser problems.

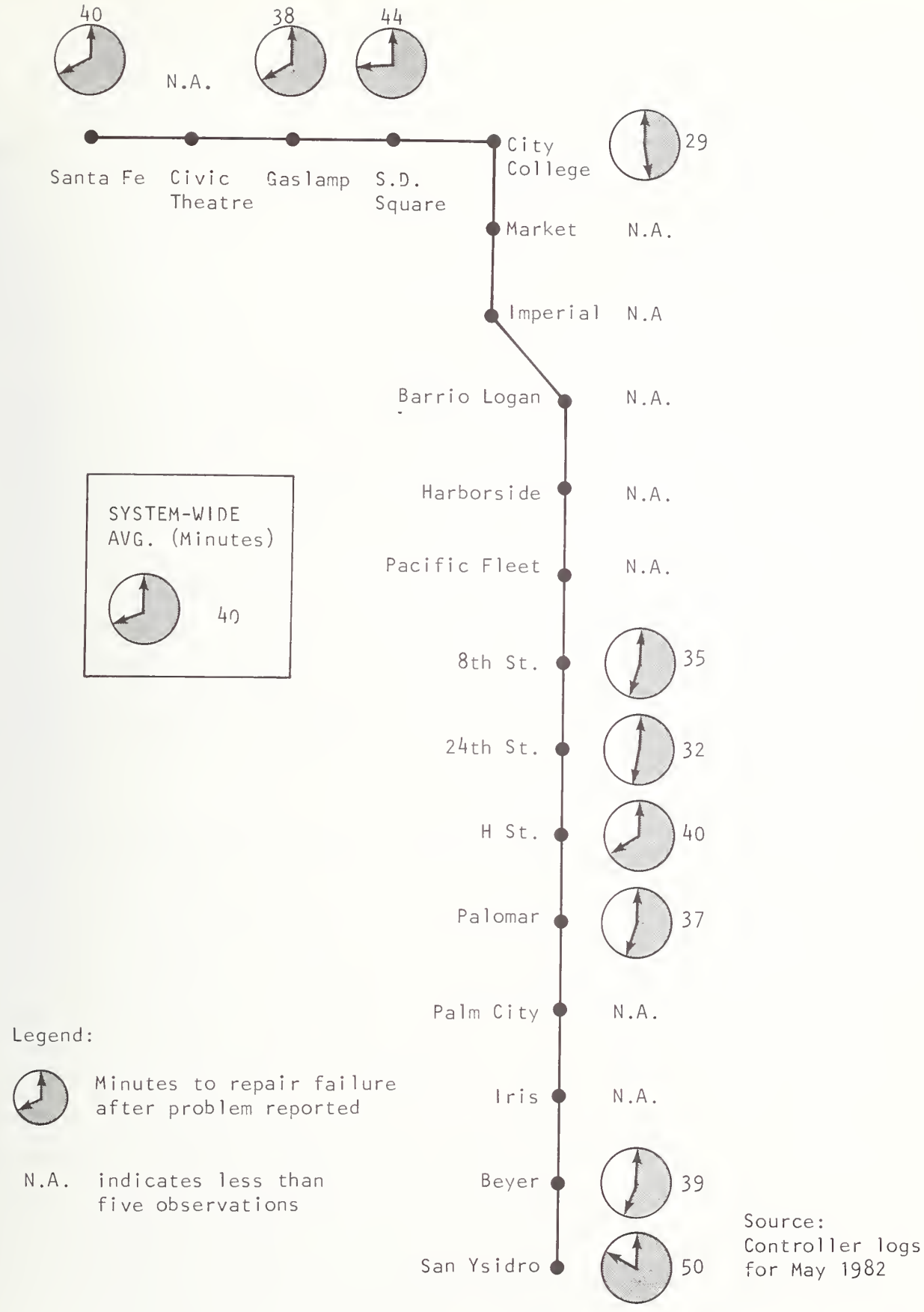


FIGURE 2-6. TIME TO REPAIR MACHINES AFTER PROBLEM REPORTED

3. TRANSIT OPERATIONS

3.1 INTRODUCTION

An advantage which is often claimed for SSFC is faster boarding and deboarding of passengers, resulting in shorter vehicle travel times, shorter travel times for passengers, and reduced equipment requirements to maintain a given headway. Two other operations issues relating to SSFC are coordination with fare payment on other modes and security in the collection of cash and distribution of tickets. This chapter presents analysis and discussion of these issues. SSFC also relieves drivers of a task regarded as onerous by some; although some improvement in job attitudes or performance may be hypothesized, no attempt was made to document or measure such a benefit.

3.2 PASSENGER BOARDING AND DEBOARDING

3.2.1 Overview of the Analysis

SSFC should speed up loading and unloading of passengers for several reasons. On boarding, passengers do not need to pause to drop money in a box or show a pass or transfer. Since the driver does not need to check for payment, the driver's seat does not need to be in the traffic pattern, slowing down passenger movements. More than one door can be used for boarding and deboarding. Because passengers use multiple doors, the tendency for loads to concentrate near the front of the vehicle, further slowing down movements, should be eliminated. This section describes an analysis of boarding and deboarding time savings,

based on measurements taken on the San Diego Trolley, using SSFC, and on two light rail lines in Boston, using conventional fare collection.

The two Boston light rail lines were the Riverside Line and the Boston College Line, both parts of the Green Line service operated by the Massachusetts Bay Transportation Authority (MBTA). These lines were chosen because boarding conditions, aside from the fare collection method, are reasonably similar to conditions on the San Diego Trolley. The above ground portions of both lines operate with no fare collection at all on outbound trips, and with conventional, on-board fare collection by the drivers on inbound trips. A comparison of boarding times on the San Diego Trolley (self service fare collection) with boarding times on Boston outbound trips (no fare collection) provides a test of overall comparability between the two sites. If conditions are comparable, similar boarding times per passenger should be observed. Then, boarding times per passenger on Boston inbound trips (conventional fare collection) would provide an indication of boarding times per passenger if the Trolley went to conventional fare collection.

A set of regression models were estimated giving time per passenger boarding and deboarding under SSFC and conventional fare collection. The coefficients of these models are compared, and the models are used to predict average time at each vehicle stop for loading and unloading. These times are then combined to estimate changes in total vehicle travel time with both fare collection methods, changes in passenger travel times, and changes in vehicle requirements.

3.2.2 Data Sources

In both sites, observers with stop watches rode the transit lines studied. At each stop they recorded the information shown in Table 3-1. Appendix A provides additional detail on data

TABLE 3-1. SUMMARY OF BOARDING TIME MEASUREMENTS

San Diego (SSFC)	Boston Outbound (No fare collection)	Boston Inbound (Conventional fare coll.)
-Total passengers boarding on each car (4 doors per car, 2 cars per train)	-Total passengers boarding at each of 3 doors (1 car per train)	-Total passengers boarding and paying cash (1 door operation, 1 car per train)
		-Total passengers boarding and using passes or tickets
-Total passengers deboarding on each car	-Total passengers deboarding at each of 3 doors	-Total passengers deboarding
-Total passengers on-board each car arriving at stop	-Total passengers on-board car arriving at stop	-Total passengers on-board car arriving at stop
-Total seconds from first door open to last door shut (independent, passenger-operated doors)	-Total seconds of passenger boarding or deboarding activity at each of 3 doors (simultaneously driver-operated doors)	-Total seconds of passenger boarding or deboarding activity (1 driver-operated door)

collection procedures and on points of similarity among the lines. Table 3-2 provides a summary of the key variables used in the analysis.

The range of values in the three data sets is remarkably similar. The major exceptions are the higher average deboardings per stop in the Boston outbound data, and the much lower average deboardings per stop in the Boston inbound data. Total loading times appear to be lower in Boston than in San Diego, but that is probably because of different definitions of this variable. The San Diego boarding times include time when doors were open but no actual boarding or deboarding activity was occurring. Because the Trolley's doors are automatic, there is a several-second, built-in delay between the end of passenger activity and the time the doors close. In the Boston outbound case, loading was

TABLE 3-2. SUMMARY OF BOARDING TIME STATISTICS[a]

	Loading Time (seconds)	Passengers Boarding	Passengers Deboarding	Passengers On-board
San Diego (SSFC)				
Mean	15.7[b]	3.4	3.5	48.3
Std. Dev.	7.7	5.0	4.8	24.5
n = 1,078				
Boston Outbound (Fare Free)				
Mean	10.0[c]	3.1	6.3	46.7
Std. Dev.	6.7	4.5	6.5	27.2
n = 211				
Boston Inbound (Conventional)				
Mean	15.4[d]	4.0	0.8	41.9
Std. Dev.	15.7	4.3	1.5	26.1
n = 550				

Notes: (a) Excludes data not used in regression analysis due to missing values for any variable. In particular, ends of the line are not included. Also excludes the driver relief point in San Diego.

(b) Time from first door open to last door shut. Data from front and back cars combined.

(c) Maximum of measurements of duration of passenger boarding and deboarding activity at each of three doors. Excludes time door open but without passenger activity.

(d) Duration of passenger boarding and deboarding activity at single door.

measured separately for each of the three doors, so total loading for the car was estimated by taking the longest of the three times at each stop. This value is probably a slight underestimate of total loading time because it ignores the possibility that the first door at which activity occurs is not also the last door at which activity occurs.

One result which stands out in Table 3-2 is that loading times are much more variable with conventional fare collection (on Boston inbound) than under SSFC or fare free operation.

Observations made at the ends of the line in San Diego were excluded from the analysis because loading times there are determined by layover times rather than passenger movements. Also observations from the Imperial stop, which is the driver relief point, were dropped from the analysis. In Boston, subway stops were not included. (There were insufficient points for a separate analysis of subway operations).

3.2.3 Regression Models of Loading Time

Several models were estimated using ordinary least squares. In all the models, the dependent variable was loading time. In the San Diego model and the Boston outbound models, total boardings, total deboardings, and total passengers on-board for each car at each stop were used as independent variables. All were expected to have positive coefficients, with boardings having a somewhat higher coefficient than deboardings, reflecting the greater difficulty of climbing on board than leaving a train. The boarding and deboarding coefficients should indicate the average increase in loading time for an additional passenger to board or deboard. If boarding conditions are similar in San Diego under SSFC and in Boston without any fare collection, then the model coefficients for the two operations should be close.

The San Diego model included zero-one variables to represent whether there was any boarding or deboarding activity at a stop. The coefficients on these variables represent extra time for the first boarding or deboarding passenger, whose time should be greater than the additional time for succeeding passengers.

Similar variables were tested in the Boston models but performed poorly, probably because of the different measurement technique used for loading time in Boston.

In Boston, in the inbound direction, the number of cash-paying passengers and the number of passengers paying with passes or tickets were included as separate independent variables. Both were expected to have positive coefficients. The coefficient for cash-payers was expected to be higher than the one for non-cash payers (especially considering the exact cash fare of $.80), and the coefficients for both were expected to be higher than one for deboarding passengers, which was also included. If the San Diego and Boston outbound models had similar coefficients, then the Boston inbound model coefficients should provide a basis for projecting loading times in San Diego under conventional fare collection.

In all the models, stops at which no one got on or off, and the measured loading time was zero, were excluded.* There is a minimum time, or fixed overhead, associated with opening and closing the doors, even if nobody gets on or off. (In Boston the observers theoretically excluded this time from their observations, but the analysis allows for the possibility that they did not do so completely.) Including the points with zero loading time would produce a downward bias in the estimates of the incremental time to board or deboard a passenger. The zero-loading time cases were added at a later stage of the analysis. In effect, a two-part model was estimated, as indicated schematically in Figure 3-1. The intercept in this model will represent the extra time, or fixed overhead, required to operate the doors.

*4.7% of cases in San Diego, 6.6% of cases in Boston outbound, and 12.9% of cases in boston inbound (all included in Table 3-2).

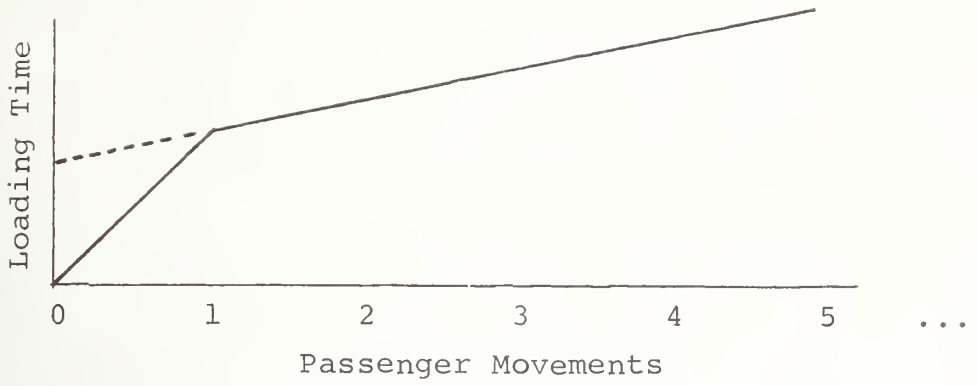


FIGURE 3-1. TWO-PART LOADING TIME MODEL

The models which are reported are simple linear models. A variety of other variables were tested including various powers, exponentials, logarithms and interaction terms. The only non-linear terms which improved any model were squares of boardings and deboardings in San Diego. The squared-term San Diego model is not used here because the squared terms have no physical interpretation; they make comparison with the Boston models more difficult; they produce only a minor improvement in model fit; and they may well be due to errors in the data collection process.

3.2.4 Similarity Between San Diego and Boston

Table 3-3 presents model results for San Diego and for the two Boston lines in the outbound direction, that is, under fare-free operation. All coefficients but one are significant at the 99% confidence level or better. That one coefficient, passengers on-board on the Riverside line, is significant only at the 82% confidence level, which would not usually be sufficient to justify retaining a variable. It is kept here because of strong prior belief that it should play a role, and to retain comparability with the remaining models.

The key coefficients to examine are the ones for boardings, deboardings and passengers on-board. The coefficients for San Diego and the Riverside line are nearly identical; differences are much much less than the estimated standard errors. Comparing San Diego and the Boston College line, the coefficients differ

TABLE 3-3. MODEL RESULTS FOR SAN DIEGO AND BOSTON OUTBOUND

	Intercept	Any Boardings	Any Deboardings	Total Boarding	Total Deboarding	Passengers On-board	R^2	Std. Error
San Diego (SSFC)								
Coefficient	8.14	1.91	1.12	0.67	0.59	0.034	.43	5.4
Std. Error	(.54)	(.43)	(.45)	(.04)	(.04)	(.007)		
Student's t	(15.0)	(4.4)	(2.5)	(17.4)	(14.9)	(4.8)		
Prob.(coeff=0)	(<.0001)	(<.0001)	(.01)	(<.0001)	(<.0001)			
Boston Outbound (Free Fare)								
Riverside								
Coefficient	3.04	not	not	0.65	0.61	0.040	.68	3.8
Std. Error	(1.21)	used	used	(.08)	(.10)	(.030)		
Student's t	(2.5			(7.7)	(6.2)	(1.4)		
Prob.(coeff=0)	(0.1)			(<.0001)	(<.0001)	(.18)		
Boston College								
Coefficient	2.96	not	not	0.84	0.52	0.029	.84	2.8
Std. Error	(.50)	used	used	(.06)	(.04)	(.010)		
Student's t	(6.0)			(13.8)	(13.2)	(3.0)		
Prob.(coeff=0)	(.0001)			(<.0001)	(<.0001)	(.004)		

somewhat more, but still not by a lot compared to the standard errors. The only difference which, it appears, may be significant in the statistical sense is in the boarding coefficients.* Even this difference, which is 0.17, is not large in a practical sense.

Overall, the incremental effect on loading time of an additional passenger boarding, deboarding, or on-board the vehicle is very similar in Boston and San Diego. The difference in the intercept terms is believed to represent the differences in the measurement procedures which were discussed in the previous section. The failure in Boston of the zero-one variables ($t<0.9$) is believed to stem from the same difference in procedures.

3.2.5 Loading Times with Conventional Fare Collection

Table 3-4 presents the results of a model estimated on the combined Boston inbound observations with conventional fare collection. With the exception of the intercept, all the terms are highly significant. All the coefficients are at least twice as large as the corresponding coefficients in the San Diego and

TABLE 3-4. BOSTON INBOUND MODEL RESULTS

	Intercept	Boarding Paying Cash	Boarding Non-cash	Deboarding	Passengers On-board
Coefficient	0.21	3.12	1.94	1.61	0.087
Std. Error	(.89)	(.16)	(.19)	(.28)	(.017)
Student's t	(0.2)	(19.8)	(10.1)	(5.8)	(5.1)
Prob.(coeff=0)	(.82)	(<.0001)	(<.0001)	(<.0001)	(<.0001)

$R^2 = .66$ Std. Error = 9.1

*While it is not a statistically rigorous procedure, using the square root of the sum of the squares of the standard errors provides a sense of the standard error of the difference of the coefficients. In this case, it is about 0.07, or half the difference, which would make the difference significant at the 95% confidence level.

Boston outbound models. As expected, cash paying passengers take considerably more time to board than do those paying with passes or tickets. Non-cash paying passengers take more time than passengers boarding under SSFC or fare-free operation, presumably because of having to board through a single door. The same logic would apply to deboarding passengers. Figure 3-2 provides a graphical comparison of the conventional fare collection (Boston inbound) and SSFC (San Diego) models. In the figure, all the independent variables except for boarding passengers are set equal to their mean values.

The model in Table 3-4 cannot be applied directly to projecting average loading times on the San Diego Trolley under conventional fare collection. In order to make the projection comparable to the existing, measured loading times under SSFC, the difference in procedures used to measure loading time must be taken into account. The San Diego measurements include the total time doors were open, while the Boston measurements included only the duration of passenger movement through the doors. This difference is reflected in the large and significant constant term in San Diego, and the significant zero-one terms in San Diego representing whether any passengers got on at all or got off at all.

The solution is to construct a composite model using the constant and zero-one coefficients from the San Diego model and the remaining coefficients from the Boston inbound model. The resulting model (including an adjustment to account for the zero-time cases excluded from the model estimation process) is as follows:*

$$\begin{aligned}\text{Loading time} = 7.76 &+ (1.91)(\text{Any Boardings}) \\ &+ (1.12)(\text{Any Deboardings}) \\ &+ (3.12)(\text{Cash Boardings}) \\ &+ (1.94)(\text{Non-cash Boardings}) \\ &+ (1.61)(\text{Deboardings}) \\ &+ (0.87)(\text{Passengers On-board})\end{aligned}$$

*The adjustment consists of using the average values in Table 3-2 (which include the zero-time cases) and reducing the San Diego constant term of 8.14, reported in Table 3-3, by 4.7%, which is the percent of zero-time cases.

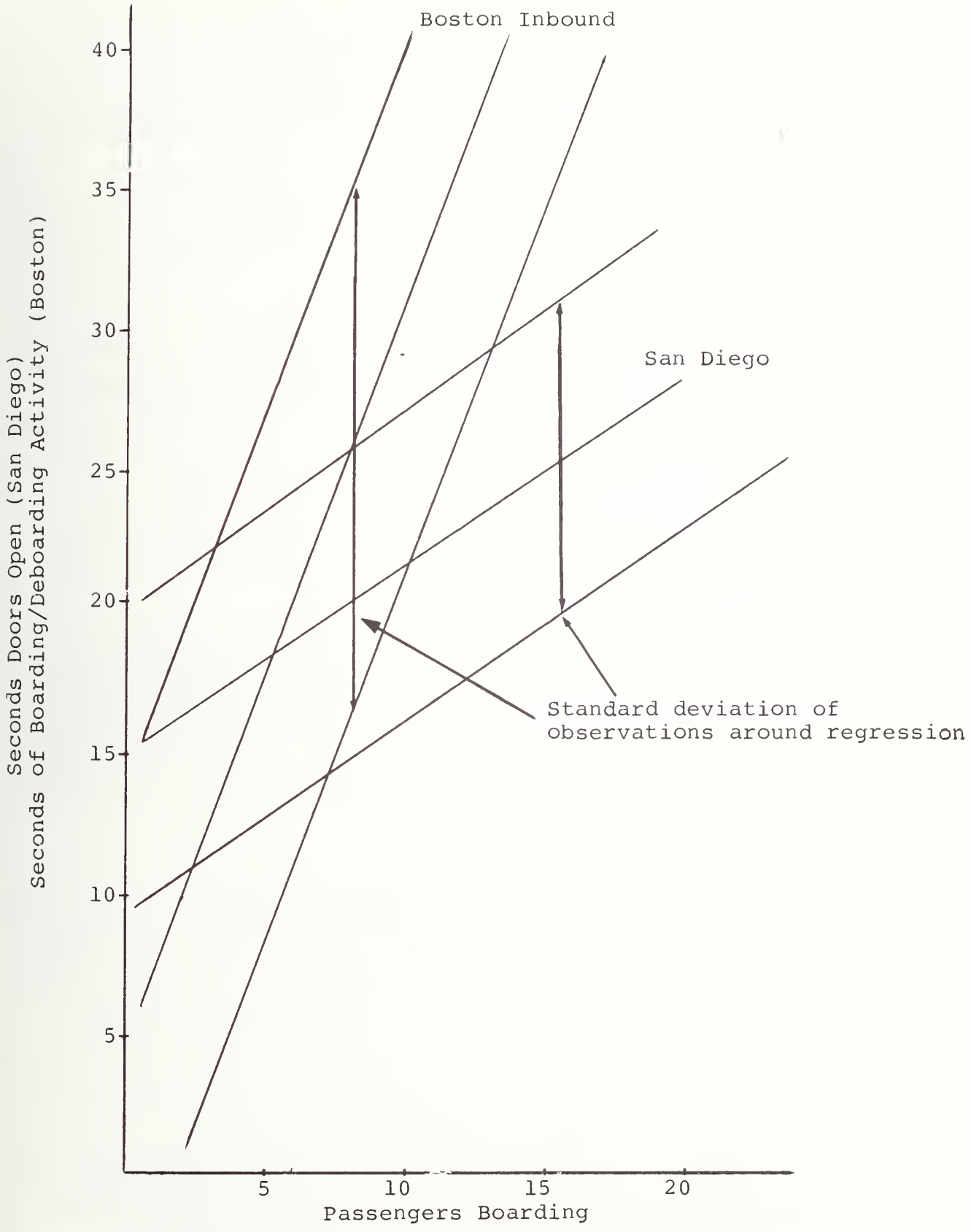


FIGURE 3-2. SAN DIEGO AND BOSTON INBOUND MODELS

In order to apply this model to the San Diego Trolley the mean values of the variables as measured on the Trolley are substituted. The required values are contained in Table 3-2, except for : 1) the zero-one variables (Any Boardings and Any Deboardings), for which the values are 0.64 and 0.70 respectively; and 2) the percentage of passengers who will not pay by cash, which is assumed to remain at its current average of about 40%. The calculation is:

$$\begin{aligned}\text{Average loading time per stop} = 7.76 &+ (1.91)(0.64) \\ &+ (1.12)(0.70) \\ &+ (3.12)(3.4)(0.6) \\ &+ (1.94)(3.4)(0.4) \\ &+ (1.61)(3.5) \\ &+ (0.087)(48.3) \\ = 28.6 &\text{ seconds per stop*}\end{aligned}$$

By comparison, the measured average loading time per stop under SSFC, as reported in Table 3-2, is 15.7 seconds. The projected increase is 12.9 seconds per stop, which would amount to an average of 3.4 minutes summed over the Trolley's 16 non-terminal stations.

3.2.6 Impact on Vehicle Travel Times

The calculation in the previous section suggests that a Trolley trip, from one end of the line to the other, would take about 3.4 minutes more with conventional fare collection. This increase represents an average over all passenger loads over

*A 95% confidence interval is ±2 seconds, computed from the estimated variances and covariances of the coefficients in each of the component models, and taking into account the difference between the assumed mean values in San Diego and the mean values of the data in Boston on which the last four coefficients were estimated. Given the many assumptions used to produce the projected loading time, however, a "practical confidence interval" would have to be much wider.

an entire day. The change on any particular trip would vary considerably from this average.

A detailed analysis of variation in vehicle travel time would require a simulation incorporating variations in passenger arrival rates and interaction between loading times and passenger boardings at succeeding stops. However, a review of the results of the analysis done here suggests the approximate change in variability which could be expected.

From the summary statistics in Table 3-2 and the regression results in Tables 3-3 and 3-4, it can be seen that the standard deviation of loading times is consistently equal to the variable part of the average loading time (see Table 3-5).

TABLE 3-5. COEFFICIENTS OF VARIATION FOR THE VARIABLE PART OF LOADING TIME

	San Diego	Boston Outbound	Boston Inbound
Mean Loading Time/Stop	15.7	10.1	15.4
Regression Constant	8.1	3.0	0.2
Variable Loading Time/Stop	7.6	7.1	15.2
Standard Deviation	7.7	6.7	15.7
Coefficient of Variation	1.01	0.94	1.03

Applied to the projected loading time under conventional fare collection in San Diego, a standard deviation of about 20.8 seconds would be expected, or nearly three times the value with SSFC.

The variance in total vehicle travel time due to loading would be somewhat more than the simple sum of variances for each stop because loading times among stops are positively correlated. The average correlation is about 0.1. It follows that the standard deviation of total loading time per trip would increase from 50 seconds to 130 seconds.

For the purpose of scheduling, a conservative estimate of vehicle travel time is needed, one which will rarely be exceeded. As an indication of the additional time which would have to be added to schedules under conventional fare collection, the estimated means and standard deviations were used to compute the 90th percentile of vehicle travel time. Five to six minutes would have to be added to the scheduled vehicle travel time.

3.3.7 Vehicle Requirements

The current operating schedule for the San Diego Trolley uses five trains to provide 20-minute headways. The schedule shows a planned one-way travel time of 42 minutes per train, with eight minutes allowed at each end of the line before the train leaves again in the opposite direction. The projected increase in the 90th percentile of running time by five to six minutes, 12% to 14% of the current scheduled running time, would reduce the layover time to two or three minutes, which is probably not acceptable. Adding one train would be a 20% increase in vehicles, which might not be a reasonable response. Instead it is possible that other sources of time savings might be sought. It is not clear whether, at the Trolley's scale of operations, the time difference would have an effect on vehicle requirements. With a larger operation, it is possible that an effect approximately equal to the projected change in scheduled time, i.e., 12% to 14% could occur.

3.2.8 Passenger Travel Times

Based on survey results, the average passenger rides for about 28 minutes and 11 stops. Counting half the boarding time at the passengers's own boarding and deboarding stops, and using a difference of 12.9 seconds for the average stop, then conventional fare collection would add 142 seconds, or 2.4 minutes, in on-board travel time to the average passenger trip. Unreliability of passengers' on-board travel time would also be increased.

The increased variation in vehicle travel times under conventional fare collection would also increase variability in

train arrival times at stations other than the ends of the line. As a result wait times for some passengers would increase.

3.3 OTHER OPERATIONS IMPACTS

3.3.1 Coordination with Other Modes

Procedures for fare payment when transferring between the Trolley and buses are confusing to many passengers, according to statements made by the ticket inspectors. Only 5% of repeat riders surveyed on-board the Trolley said they understood how to pay when transferring (see Section 5.1.2).

The procedure is, in fact, a little complicated. When transferring from the Trolley to a bus, a valid Trolley ticket or validated multi-ride ticket serves as a transfer. When transferring from a bus to the Trolley, the procedure depends on whether the bus was a local one or a metro/express one. Since the local bus fare is $.80, a local bus passenger must request a transfer, buy an upgrade ticket costing $.20 from a Trolley ticket machine, and retain both to show a ticket inspector. A passenger on a metro or express bus, for which the fare is $1.00, as on the Trolley, can request a transfer and use it for proof of payment on the Trolley without any upgrade ticket.

MTDB and the bus operators considered the possibilty of allowing local bus passengers to buy a metro/express transfer by paying the extra $.20 on the bus, so that upgrade tickets would not have been needed. MTDB would then have wanted to collect the $.20 paid by such passengers from the bus operators. Since there was no way for MTDB to collect the transfers, the bus operators would have had to pay based on the sample counts taken by the ticket inspectors. Based on the need for a revenue transfer, and the need to base it on sample counts, the general managers of the operators decided against such an arrangement. There have been observations, however, that some bus drivers do sell metro/express transfers on local buses, contrary to the rules. Also, passengers occasionally complain that bus drivers give them incorrect information about transferring to the Trolley.

3.3.2 Security in Cash Collection

An SDTI employee, accompanied by an officer of SDTI's contract security force, visits each stop between one and three times daily, depending on the stop, removes the ticket machine cash vaults and replaces them with empty ones. The cash vaults with money in them are then taken to a revenue processing room at SDTI's headquarters, where the money is bagged. A deposit slip is prepared based on the record slips automatically printed out by the ticket machines when the cash boxes are exchanged. The bagged money is picked up by an armored truck at the end of each day and taken to the bank, where it is counted. The bank's count of revenue is compared to the deposit slips. The two generally agree within 0.04%, and SDTI accepts the bank's count as correct. The bank picks up and counts the coins, which amount to about $6,000 each day, without charge.

3.3.3 Distribution of Tickets

Ticket stock is carried by SDTI maintenance personnel who put it in the machines as needed in the course of their normal rounds. No special precautions are taken to guard against losses because blank ticket stock is considered to be of no value. During very early stages of Trolley operations, tickets were occasionally hand validated. The policy was soon changed, so that only machine-printed tickets are valid. To use a blank ticket, therefore, a person would have to have a printer capable of simulating the one in the ticket machines. There are some risks in the distribution of multi-ride tickets to the outlets were they are sold. However, such risks are independent of whether self-service or driver validation is used.

4. ENFORCEMENT

4.1 LEGAL AUTHORITY

4.1.1 Legislation

MTDB was created by a 1975 act of the California legislature as an independent organization, with a board of directors representing the various governments in the San Diego area. This enabling act (Public Utilities Code Section 120050 et seq.) provided authority for MTDB to "acquire, construct, maintain, and operate (or let a contract to operate) public transit systems and related transportation facilities and services as it deems necessary." Further, the act empowered the board to "do any and all things necessary to carry out the purposes" of the act (Section 120105(g)).

In late 1979, about a year and a half before service began, MTDB requested a legal opinion on whether its existing legislation gave it the authority to fix and collect fares, demand proof of payment, and enforce penalties for non-payment of fares. The resulting legal opinion[1] recommended that, although the existing legislation might be sufficient, MTDB should seek amendments to its enabling act to provide it authority to fix and collect fares, and to enforce fare payment. The opinion stated that MTDB could already adopt rules and regulations requiring passengers to show proof of fare payment. The opinion states, "Such a requirement could be implemented by including it in the operating rules and regulations of the transit system and by printing the requirement on each ticket or pass, as well as by posting the requirement at station sites and on vehicles." The opinion suggests possible language for amending the enabling act.

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[1] Memorandum to Paul A. Peterson and Thomas F. Larwin from Gregory C. M. Garratt, "Fare Collection Legislation," November 26, 1979.

MTDB did seek to have its enabling act amended, so that in 1980 two sections were added giving the board broad powers. Public Utilities Code Section 120105(e) states that the board shall:

> Adopt all ordinances and make all rules and regulations proper or necessary to regulate the use, operation, and maintenance of its property and facilities, including its public transit systems and related transportation facilities and services operating within its area of jurisdiction, and to carry into effect the powers granted to the board.

More specifically relating to fare collection, Section 120450 states:

> Violation of any ordinance, rule, or regulation enacted by the board relating to the evasion of the payment of a fare in any transit facility owned or controlled by the board shall be an infraction punishable by a fine not exceeding fifty dollars ($50), except that such a violation by a person, after the second conviction under this section, shall be a misdemeanor punishable by a fine not exceeding five hundred dollars ($500) or by imprisonment not exceeding six months, or by both such fine and imprisonment.

4.1.2 Implementation

As of early 1981, a few months before the start of service, MTDB was considering three options for enforcement of fare payment. These were enforcement by 1) MTDB employees, 2) by a private security contractor, or 3) by an existing law enforcement agency, such as a municipal police department or the county sheriff, under contract to MTDB. A letter from MTDB's legal counsel outlined the advantages and disadvantages of each approach.[2] An advantage of using MTDB employees is their authority to arrest persons violating MTDB ordinances and to issue citations. This authority comes from Section 836.5 of the California Penal Code, which states:

> The governing body of a local agency, by ordinance, may authorize those of its officers and employees who have the duty to enforce a statute or ordinance to arrest persons for violations of each statute or ordinance . . .

Section 836.5 also allows arrests without a warrant based on

[2] Letter to Thomas F. Larwin from Peterson, Thelan & Price, April 13, 1981.

reasonable cause, provides protection from suits against false arrest or imprisonment, and provides for issuing a notice to appear in court (citation).

The same authority would be enjoyed by peace officers of a police department under contract to MTDB, who, in addition, would be able to make arrests and issue citations for violations of laws other than MTDB ordinances. The primary disadvantages of using police officers would be lack of control by MTDB, a harsher image than desired, and probably, cost.

A private security force would give MTDB greater control than police, and would relieve MTDB of the need to hire and train its own employees. On the negative side, security guards, like police, would project a different image than the public service image desired by MTDB. Also, employees of a private security force would not be able to issue citations or make arrests, except as a "citizen's arrest." In this case, it would be desirable to impose civil rather than criminal penalties. Under a civil procedure MTDB would have to sue a non-paying passenger, presumably after seeking voluntary payment of a premium fare. Such an approach is being used in Portland, OR, in a demonstration of SSFC funded by SMD.

MTDB chose to hire its own ticket inspectors and to issue citations for failure to possess or show proof of payment. MTDB Ordinance No. 2, passed by the board on June 8, 1981, defines the duties of ticket inspectors, specifies what constitutes proof of payment, establishes the requirement to show proof of payment and the procedure for issuing a citation, and fixes the penalty for fare evasion. The text of the ordinance is contained in Appendix C.

MTDB Ordinance No. 2 states that violations are infractions punishable by a fine not exceeding $50, and that a second conviction is a misdemeanor punishable by a fine not exceeding $500, imprisonment not exceeding six months, or both. It further provides that "a bail forfeiture shall be deemed to be a conviction of the offense charged." The ordinance does not establish the bail amount, which for practical purposes is the fine for fare evasion. Bail for violations of MTDB ordinances, and all other local agency ordinances, is set by a committee of judges for San Diego County,

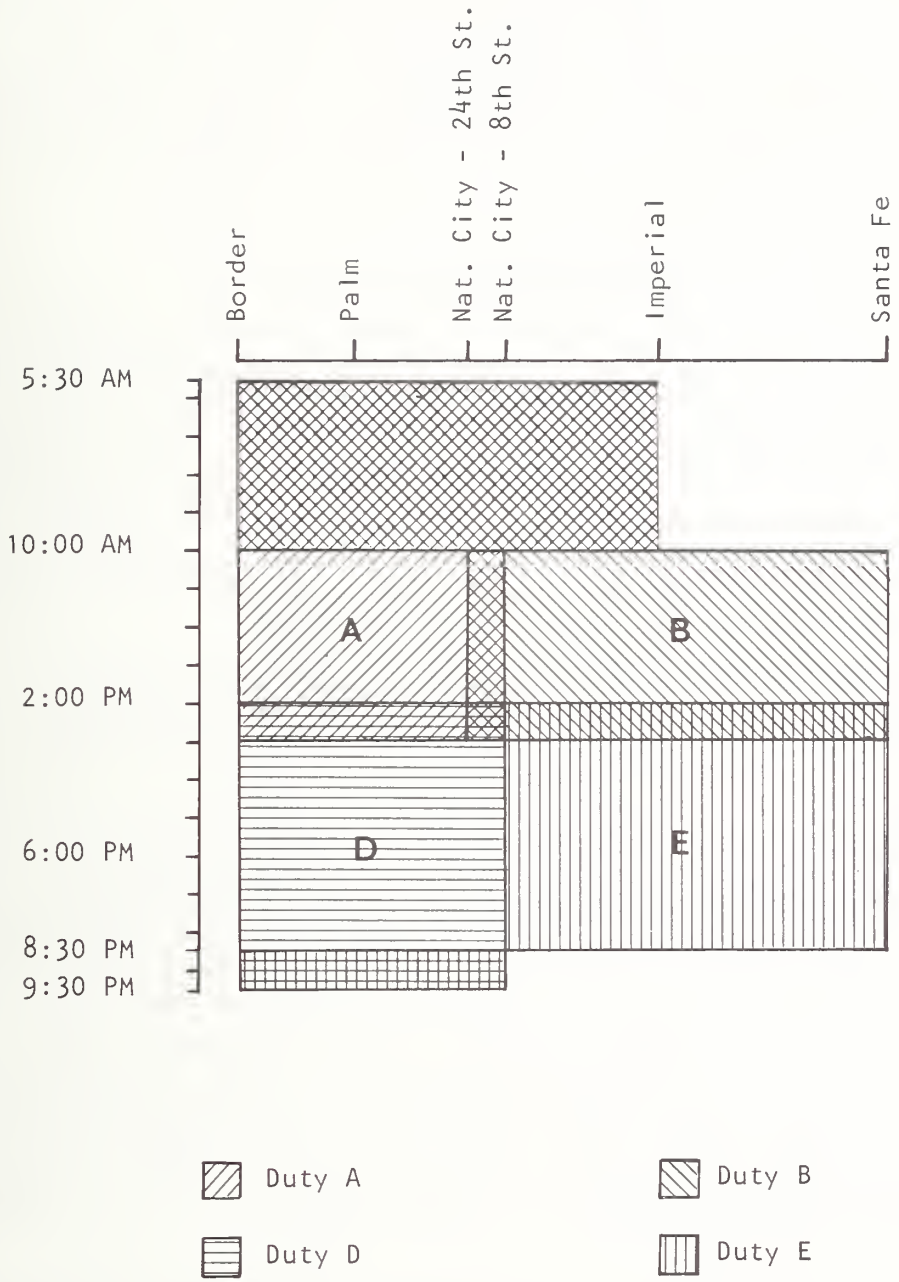
which periodically issues a revised schedule of recommended bail amounts. Bail for violations of MTDB Ordinance No. 2 is set at $20. This amount was presumably set based on the recommendation of MTDB staff. In addition, the court collects a $10 "penalty assessment." For purposes of comparison, bail for parking meter violations is $8, while for most other parking violations, such as blocking a fire hydrant, it is $12. MTDB Ordinance No. 3 regulates parking in San Diego Trolley parking lots; the bail for violations is $50.

4.2 PROCEDURES

4.2.1 Inspections

Fare payment on the San Diego Trolley is enforced by a team of inspectors who are employees of MTDB and have limited police powers to enforce fare payment and other MTDB ordinances. The full authorized inspection force consists of five full-time employees. Four are assigned to eight-hour duties Monday through Thursday, while three are assigned to duty Friday through Sunday. On occasion, one duty has not been covered due to staff vacancies, illness, etc. The inspectors report to a supervisor of fare inspection, also an MTDB employee. Each duty consists of covering a portion of the line, as illustrated in Figure 4-1. Within the assigned line segment, the inspector is instructed to ride different trains, of the inspector's choosing, each day. The inspectors report that they follow no particular pattern. Chance events, such as when they get off to help a person buy a fare, and surveys required as part of the passenger counting program, help them to randomize their inspections. In the year ending October 1982, between 33% and 44% of passengers were inspected each month.

An inspector boards a car at one end and checks every passenger, moving to the other end, requesting each passenger to show one of the valid forms of proof of payment (single-ride ticket, validated multi-ride, monthly pass, express bus transfer, local bus transfer plus upgrade ticket). When all passengers have been checked, the inspector gets off at the next station and



(Duty C covered Palm to Imperial, 10:00 AM to 6:00 PM, but was discontinued due to lack of staff.)

FIGURE 4-1. TICKET INSPECTOR ASSIGNMENTS (Monday-Thursday as of 5/4/82)

either boards the other car on the train or waits for another train. The inspectors keep track of the trips they ride, the number of passengers checked, the number of fare evaders contacted and the number of citations issued using the form shown in Figure 4-2.

4.2.2 Treatment of Fare Evaders

If a passenger does not show a valid proof of payment to the fare inspector, the inspector may issue a citation (Figure 4-3), or Notice to Appear in court on the charge of fare evasion. MTDB's initial policy was to cite most fare evaders, with few exceptions. After one month of operations new guidelines were issued, giving the inspectors more direction about when not to issue a citation. These state:

> After the passenger presents identification or identifies himself orally, a citation will be issued except under certain circumstances. Guidelines for discretion are as follows:
>
> A. Consideration will be given to the validity of the passenger(s) explanation, particularly if he/she is from out of town. If in the Inspector's mind no attempt was made to evade the fare and the passenger(s) is willing to purchase a ticket, you may allow him/her to exit the train at the next stop to do so. The Inspector will, however, give the passenger(s) a warning ticket (Figure 5.1A) and/or a copy of the MTDB brochure on the Trolley fare structure in the appropriate language. The Inspector will also obtain a full name and address of the passenger(s) for constant updating of the Fare Evader List.
>
> Discretion should also be considered when dealing with the elderly and the final decision resting with the Inspector.
>
> B. In cases where a fare machine malfunctions, the Inspector may issue a citation in lieu of a fare. If a citation is written it should be accompanied with an explanation that if the fare machine is found to be defective by the Inspector or maintenance crew, the citation will be dismissed and the individual will be notified.

DAILY TICKET INSPECTION REPORT

Name: _____ Starting Citation No. _____

Date: _____ Ending Citation No. _____

Day: _____ Page _____ of _____

Shift: Duty:

Time	Direction (Circle)	Station	Car #	Passengers	Fare Evaders	Citations	Remarks Surveys
	E W						
	E W						
	E W						
	E W						
	E W						
	E W						
	E W						
	E W						
	E W						
	E W						
	E W						
	E W						
	E W						
	E W						
	E W						
	E W						
	E W						
	E W						
	E W						
			F.E./Cite Totals:				

FIGURE 4-2. DAILY TICKET INSPECTION REPORT FORM

SAN DIEGO
METROPOLITAN TRANSIT DEVELOPMENT BOARD **COURT COPY**

NOTICE TO APPEAR Z 09000

DATE 19	TIME M	DAY OF WEEK	ADULT / JUVENILE

NAME (First, Middle, Last)

RESIDENCE ADDRESS CITY STATE ZIP

BUSINESS ADDRESS CITY STATE ZIP

DRIVERS LICENSE NO	STATE	SOCIAL SECURITY NO	BIRTHDATE

SEX M F	HAIR	EYES	HEIGHT	WEIGHT	AGE

VIOLATION ORDINANCE NO	DESCRIPTION
☐	MTDB ORDINANCE NO 2 — FARE EVASION
	BOOKING REQUIRED ☐

LOCATION OFFENSE(S) COMMITTED

I CERTIFY UNDER PENALTY OF PERJURY THAT THE FOREGOING IS TRUE AND CORRECT
EXECUTED AT THE PLACE AND ON THE DATE SHOWN ABOVE

☐ OFFENSE(S) NOT COMMITTED IN MY PRESENCE CERTIFIED ON INFORMATION AND BELIEF

ISSUING OFFICER I.D. NO.

NAME OF ARRESTING OFFICER IF DIFFERENT FROM ABOVE | I.D. NO.

WITHOUT ADMITTING GUILT, I PROMISE TO APPEAR AT THE TIME AND PLACE CHECKED BELOW.

SIGNATURE

JUVENILE PROBATION 2901 MEADOW LARK DRIVE SAN DIEGO, CA 92123 ☐	MISDEMEANOR ARRAIGNMENT DEPT. 220 W BROADWAY SAN DIEGO, CA 92101 ☐
SAN DIEGO MUNICIPAL TRAFFIC CT 8950 CLAIREMONT MESA BOULEVARD SAN DIEGO CA 92123 ☐	SOUTH BAY MUNICIPAL COURT 500 3RD AVE. CHULA VISTA, CA 92010 ☐

TO APPEAR	TIME AM ☐ PM ☐	MONTH	DAY	YEAR

CRC (P) M

FIGURE 4-3. CITATION

> On occasion all fare machines at the Depot and San Ysidro have malfunctioned, making the purchase of fares impossible. Under these conditions, passengers will be allowed to board the trains and ride for free. Inspectors will be notified immediately via radio of the problem so that citations will not be written.

In general, whenever a fare machine is known to have failed, passengers from that station ride for free. One excuse which is not accepted is that the passenger did not have sufficient change to buy a ticket. The inspectors report that, as they and the passengers gain more experience, it is becoming easy to decide whom to cite in most cases. However, two inspectors complained about having to cite passengers who did not buy a ticket due to lack of change. In the year ending October 1982, an average of 66% of fare evaders contacted were given citations.

In order for a citation to be issued the passenger must give his or her name and address, and ideally show identification and sign the citation. Identification and a signature are not absolutely necessary, but a correct name and address obviously are. According to the Standard Operating Manual issued to the ticket inspectors:

> If the passenger refuses to give the inspector identification or state his name and address, the inspector must warn the individual that he is subject to arrest and call for assistance by radio if the passenger continues to refuse. The inspector should avoid confrontation at this point even if it means moving on to another part of the LRT car until assistance arrives.

The inspectors radio SDTI's contract security force, whose officers are armed, telling them to meet the train at the next station. At the next station the inspector deboards with the passenger to wait for security. When security arrives, if the passenger has not already fled, as often happens, the security officer again asks the passenger to provide identification. If the passenger continues to refuse, the security officer calls the appropriate police

force, depending on the station location, who repeat the procedure and may eventually arrest the passenger.

MTDB's supervisor of inspection estimates that 99% of cited passengers give a name and address and sign the citation. Some passengers refuse to show identification, but give verbal identification; two inspectors estimate that 5% to 10% of fare evaders give verbal or no identification. An unknown percentage (believed to be small by MTDB) give false information, an act which, under a new MTDB ordinance effective January 1984, will be a separate punishable infraction. MTDB routinely checks a sample of citations against a criss-cross directory and records of the State Department of Motor Vehicles in order to correct or detect false information.

On the average, at least once a day, and about eight-to-ten times a week, an inspector calls security for assistance. These cases usually end with the passenger signing the citation; the remainder usually flee unless a security officer has arrived by the time the train reaches the next station. Of five inspectors interviewed, four stated that additional security would be desirable to provide timely assistance when called for.

4.2.3 Legal Procedures

The citation issued to fare evaders is a "Notice to Appear" in one of three courts, as checked at the bottom of the form, to answer the charge of violating MTDB Ordinanace No. 2. The citation functions like a traffic citation. The person cited receives a "courtesy notice" from the court saying that they must post bail or appear in court for arraignment by the date given on the Notice to Appear, generally three weeks after the date of the offense. Bail, which is set at $20, plus a state imposed $10 "penalty assessment," is intended to be forfeited and to function as the fine in most cases. A small number of citations (3% in September and October 1982) are voided by the MTDB inspection supervisor, primarily in cases where a ticket machine was not operating.

A person who does not wish to pay the $20 bail may go to court for arraignment. In this case, most people plead guilty, are given the opportunity to explain any extenuating circumstances, and pay the fine set by the judge. The judge can fine fare evaders up to $50, but usually imposes a fine lower than the bail amount, typically $5, or imposes a suspended fine.

Only if a person pleads not guilty does a case go to trial. In the South Bay Municipal Court, which has jurisdiction in about 40% of the cases, the trial can be an "instant trial", conducted by mail. The defendant and the MTDB ticket inspector each submit written statements (called Declarations of Facts), giving their versions of the events. The judge reaches a verdict based on the written statements. In the other courts (San Diego Municipal Traffic Court and the Juvenile Probation Department) trials require court appearances. MTDB records show that ticket inspectors were subpoenaed to testify 41 times in 1982 and received 77 court requests for Declarations of Facts in the year and nine months after service began.

If a person neither posts bail nor goes to court by the date given on the Notice to Appear, the court waits an additional 30 days, and if the individual has still not responded, turns the case over to the Marshal's office of San Diego County which issues a warrant for the person's arrest. The Marshal's office can send a "notify warrant" in the mail, or serve the warrant in person. Since the Marshal's office has over 200,000 outstanding warrants, MTDB fare evaders probably receive a notice in the mail in most cases. On receiving notice of a warrant, a person still has the options of posting and forfeiting bail or going to court. Police anywhere in California can, on stopping a person for any offense, obtain a records check which will show these warrants. The warrants are purged after three years.

4.2.4 Administration

The administration of the program is conducted by the fare inspection supervisor, and includes record keeping and monitoring field supervision and liaison contacts with various agencies. All citation and warning information is kept in computer files for statistical purposes and immediate retrieval of information. Repeat violators are identified and periodic lists posted. Monthly reports are submitted pertaining to inspection coverage and percentage of nonpayers. Occasional follow-up is necessary on field-related incidents and arrests, always working closely with investigating officers from the respective agency. Any needed change in procedure is accomplished by amendments to the fare inspection manual and periodic in-service training of all inspectors with review and approval of new procedures from the MTDB's General Counsel.

4.2.5 Coordination with Other Law Enforcement Agencies

The Trolley travels through areas under the jurisdiction of four law enforcement agencies: the San Diego Police Department, the National City Police Department, the Chula Vista Police Department, and the Sheriff's office for San Diego County. Two other law enforcement agencies that require close coordination are the Border Patrol and California Highway Patrol. The presence of law enforcement agencies has been helpful in dealing with hostile evaders and intoxicated patrons. Three of the inspectors have at one time or another been assaulted. Problems of this nature require the assistance of the law enforcement agency which has jurisdiction. The physical detaining of a person taken into custody is accomplished by the SDTI contract security force but prisoner transportation and booking must be carried out by a police agency.

Another problem which has required the presence of a police agency has been the giving of false information regarding identity

to a fare inspector by a nonpayer. Security is the immediate backup for inspectors in such cases, but if cooperation cannot be obtained from the detained subject, the police are summoned. After January 1, 1984, a new MTDB ordinance will go into effect, making it illegal to give false identity to an inspector.

4.3 COMPLIANCE

4.3.1 Fare Evasion Rates

MTDB checks a high percentage of passengers, so the records kept by the ticket inspectors are believed to provide a reasonable estimate of the actual fare evasion rate. Moreover, it is difficult for a fare evader, once on board, to avoid detection, as there is no on-board ticket vending or validation. A person who intends to ride without paying and sees an inspector about to board, or already on the train, may wait for the next train. Equally likely, however, the person will purchase a ticket that time, so no fare evasion occurs. Another way to avoid detection is for two or more people to use the same proof of payment, passing it from one person to the other when the inspector is not looking. The inspectors are aware of this technique and are on the alert to spot it. Passengers riding with no proof of payment can ride near the door and get off at any station when they see an inspector about to board. However, the inspectors often spot such people; they then attempt to cite them or at least add them to their count of fare evaders. In summary, while it is possible that measured evasion rates slightly understate actual rates, the degree of understatement is believed to be very small.

Monthly evasion rates have varied between 0.4% and 0.7% averaging 0.5% for the period October 1981 to October 1982, based on inspectors' counts. These figures include fare evaders who were not cited, but rather allowed to deboard and purchase

a ticket. Both evasion rates and inspection rates vary considerably from day to day. For example, the month of August 1982 had an evasion rate of 0.51%, close to the average for the year, but daily rates went as high as 0.72% and as low as 0.18%. The percentage of passengers checked each day also varied, between 28% and 63%, averaging 44%. A check was made for a relationship between the daily inspection and evasion rates, but none was found. A similar check found no relationship between monthly inspection and evasion rates.

4.3.2 Types of Fare Evasion

The majority of fare evasion cases involve riding with no fare at all, as shown in Figure 4-4, based on a tabulation by MTDB of a sample of 5,008 citations issued between July 1982 and October 1983. The next most frequent types are riding in the wrong direction, that is toward the machine from which a ticket was vended, and using an old ticket, that is one not issued the same day. A possible reason for the high rate of old-ticket evasion is that the date is coded on the tickets in a way most passengers would be unlikely to understand (see Section 1.3). In contrast, very few passengers attempt to use tickets on which the two-hour time limit has expired, possibly because the time coding is easier to understand. Wrong fare types, including use of a Centre City ticket beyond the downtown zone and improper use of elderly and handicapped tickets, is a relatively minor problem.

The incidence of unvalidated multi-ride tickets (including old or expired validations) is remarkably low. The MTDB supervisor of inspection believes an inconsistent policy toward unvalidated multi-ride tickets is to blame. Inspectors can hand-cancel multi-ride tickets. Especially in the case of the special two-ride tickets sold to tourists, the inspectors have been encouraged to hand-cancel the ticket rather than issue a citation.

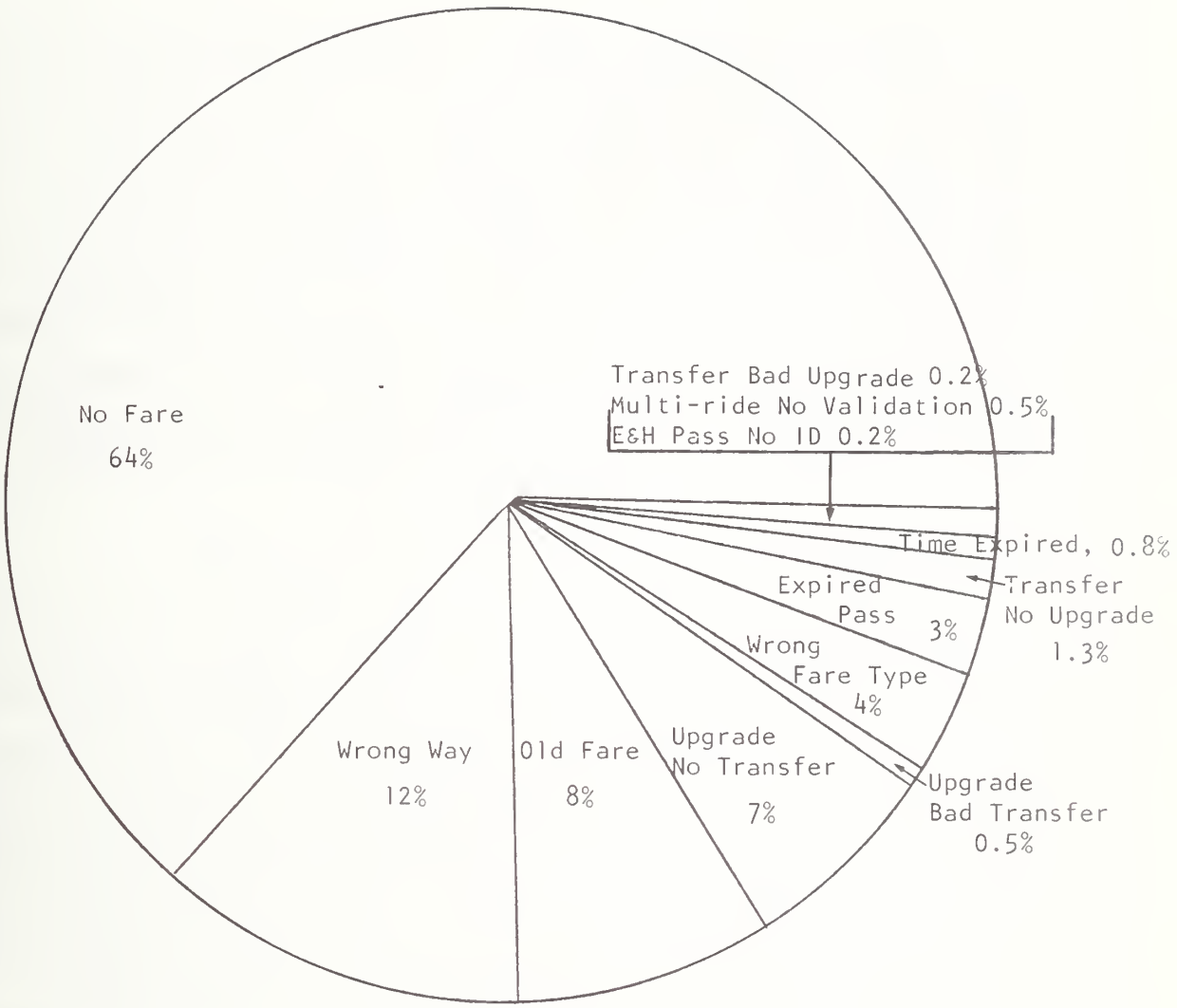


FIGURE 4-4. DISTRIBUTION OF FARE EVASION TYPES

Among all possible types of evasion relating to transfers, the majority of cases consist of having a 20-cent upgrade ticket but no transfer. MTDB staff believe that, for the most part, these cases represent intentional fare evasion rather than confusion about the use of transfers. Other types of improper transfers are use of a bad transfer (old, expired, etc.) with a good upgrade ticket, use of a good transfer with a bad upgrade ticket (old, expired, wrong direction), or both. No data are available on characteristics of the fare evaders. However, MTDB staff estimate that military patrons account for about one-third of fare evasion.

4.3.3 Outcome of Citations

MTDB has searched court records to determine the disposition of the citations issued to fare evaders. Figure 4-5 shows the disposition of 3500 citations, issued between April and December 1982, as of July 1983. Not included are citations to the Juvenile Court (about 11% of all citations) and 402 citations for which the search either found no record or a record showing no disposition. According to these records roughly one-fourth of cited passengers forfeited bail, another fourth went to court, and about half ignored the citation and subsequent courtesy notice.

Of those who went to court, about four-fifths were found guilty and assessed some penalty, as follows:

Penalty	% of Cases Found Guilty (616 Citations)
Fine	47%
Probation	26
Suspended Sentence	27

The average fine was $17, with the most frequent amounts being $5 and $25 as shown in Figure 4-6.

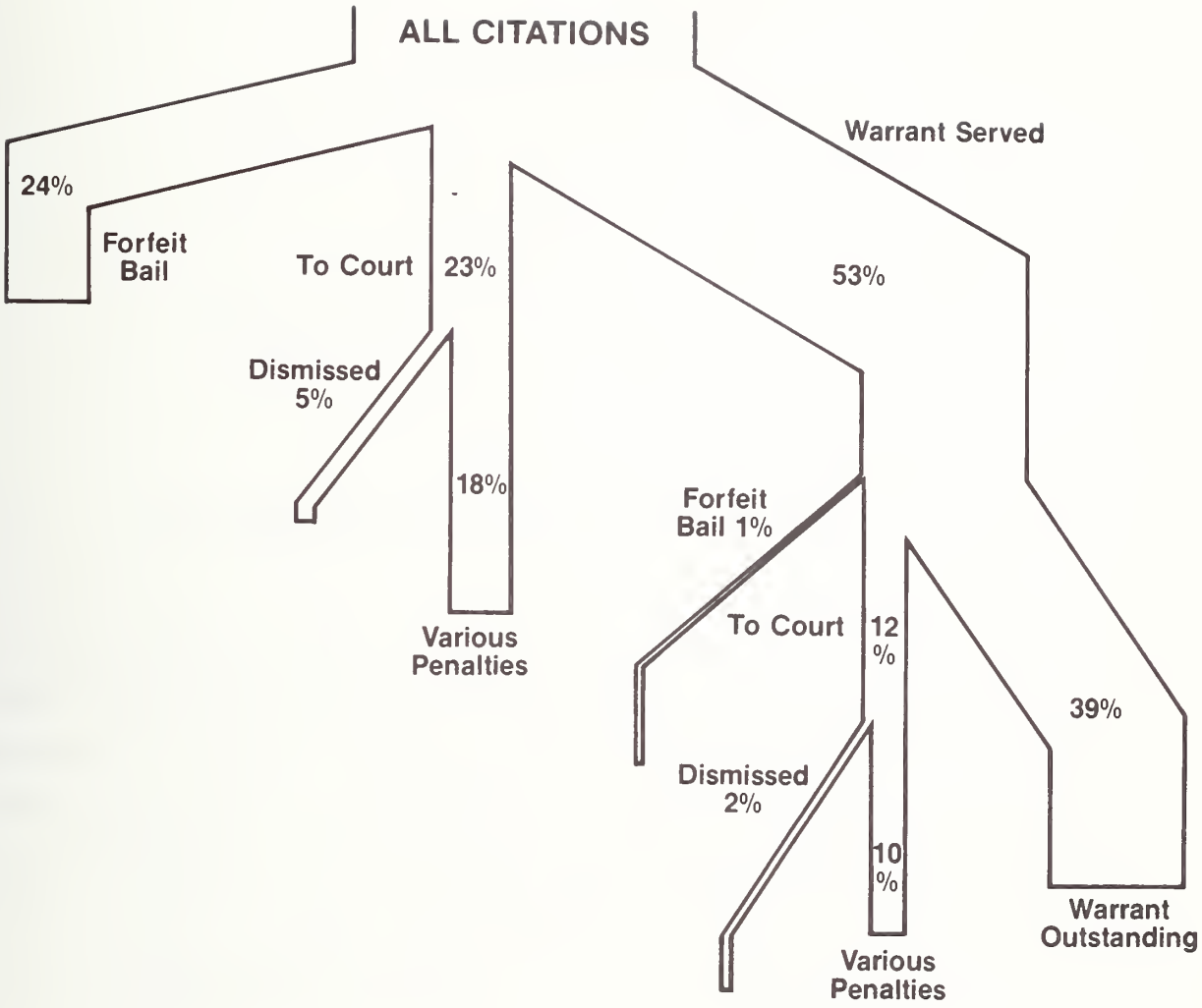


FIGURE 4-5. DISPOSITION OF CITATIONS

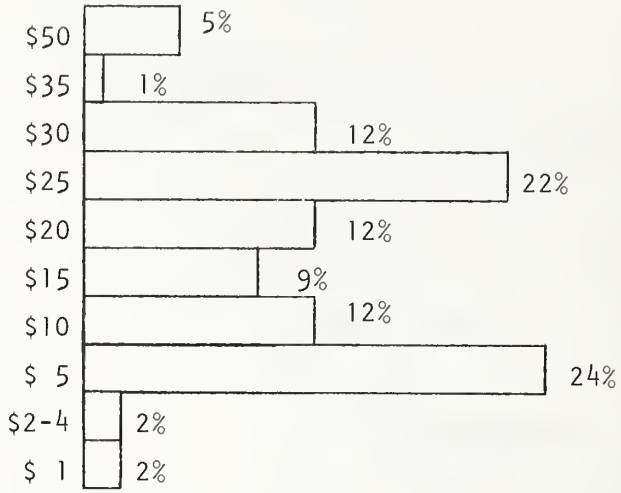


FIGURE 4-6. FINES PAID AFTER TRIAL
(260 Citations)

Of those who ignored the citation and courtesy notice, causing a warrant to be served, a little under a fourth went to court, about three-fourths did not respond, and a very few forfeited bail (usually $50) without going to court. Of those who go to court after a warrant is served, about four-fifths are found guilty and assessed some penalty, as follows:

Penalty	% of Cases Found Guilty (334 citations)
Fine	31%
Probation	1
Suspended Sentence	24
Jail	44

The average fine was $37. The most frequent fine was $40 as shown in Figure 4-7. MTDB's supervisor of inspection and the Supervisor Deputy Clerk of General Services of the Southbay Court are very skeptical that anyone has actually gone to jail

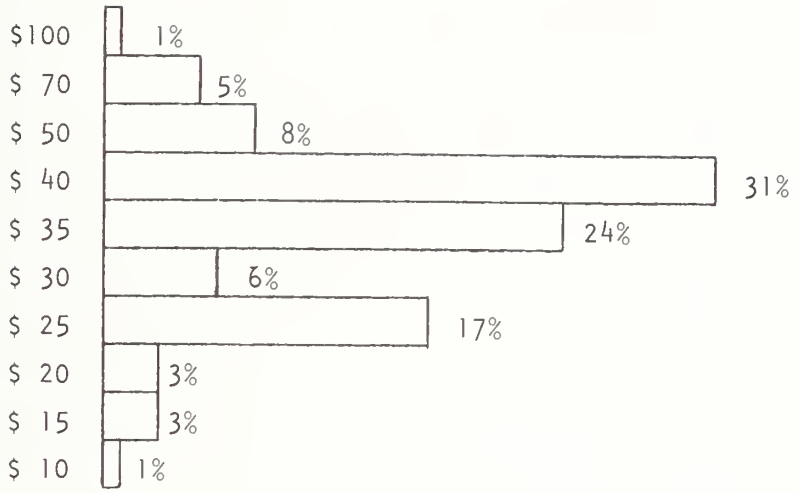


FIGURE 4-7. FINES PAID AFTER WARRANT AND TRIAL
(87 Citations)

for simple fare evasion, although MTDB's fare evasion ordinance does provide for jail terms of up to six months for repeated offenses. Many of those records with a "jail" notation may represent suspended jail terms. (The records have a single letter code for disposition, so a suspended jail term could be coded as either "suspended sentence" or "jail".) Some may be cases in which a jail term was based on some other offense in combination with fare evasion. It is possible that some individuals were picked up for some other reason, a records check showed warrants for fare evasion, and the person was sentenced to "time served", that is the time already spent in jail awaiting trial.

Jail sentences have been imposed for cases of repeated fare evasion. For example one young woman, who was picked up with 11 outstanding fare evasion warrants, was sentenced to 30 days in jail.

Several points stand out in considering the outcome of citations. One is that MTDB's citations do stand up in court.

Of all cases that went to court, only 21% were dismissed. Second, individuals who take their cases to court in response to the first notice to appear generally pay a fine lower than the bail amount. However, individuals who go to court only after receiving a warrant pay a fine higher than the bail amount. Possible reasons are that such cases involve more clear-cut instances of fare evasion or multiple offenses. Third, a substantial minority of cited persons appear to ignore the citation and subsequent notices and warrants indefinitely, and without any consequence. MTDB staff have suggested that many of these cases may be tourists and military personnel who have left the area.

Further analysis indicates that more people may eventually respond to the warrants than it seems from Figure 4-5. The plot in Figure 4-8 shows the percentage of cases with outstanding warrants* as a function of the number of months between the time the citations were issued and the time the records were

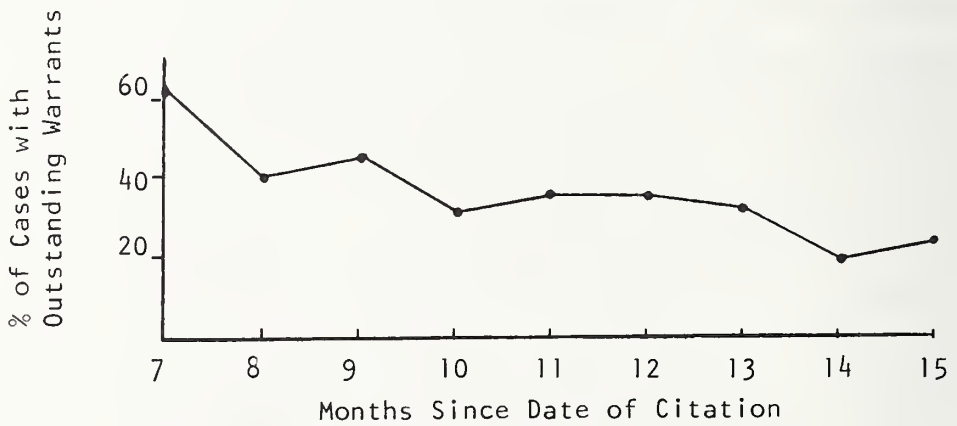


FIGURE 4-8. TREND IN PERCENT OF WARRANTS OUTSTANDING

*That is citations for which the record shows a warrant and no further disposition.

checked. The plot implies a tendency for the percentage of cases with outstanding warrants to decline over time. At this time, one can only speculate about the mechanism for such a decline, since there has been no decline in the percentage of cases resulting in warrants. For example, it might represent the time it takes the Marshal's office to work through a backlog of warrants before mailing notices to fare evaders. If the data shown in Figure 4-8 do represent a trend, the implication is that, in the long run, less than a quarter or even a fifth of cases remain undisposed of.

4.3.4 Repeat Offenders

MTDB maintains a list of repeat offenders, compiled by computer matching of citations once every four months. As of November 1982, the list included 232 persons with two or more citations, and a few with up to 10 citations. A repeat violation is a misdemeanor (as opposed to an "infraction") for which a fine up to $500 and a jail term of six months could, in theory, be imposed. The inspectors have lists of the worst known offenders, some of whom they know on sight. In one case an inspector spotted a person known as a repeat offender and called security. Security called the police who checked the person's record, found nine warrants for arrest for fare evasion, and arrested the individual. Similar cases have occurred "two or three" times according to the supervisor of fare inspection. In the future inspectors will first call the supervisor of fare inspection or the trolley controller, who will use a special telephone line to call the Marshal's office to check for warrants.

The 232 repeat offenders known to MTDB as of November 1982, amounted to about 4% of all passengers cited as of that time. If giving false identification is more likely among repeat offenders than other cited fare evaders, as seems likely, the actual repeat evasion rate would be somewhat higher. Also, a fare evader might easily ride without paying a few more times

without being caught. With the inspection rate around 40%, however, the repeat offender will be inspected again before long. Therefore, it appears that the great majority of fare evaders do not repeat their offense.

4.4 TICKET INSPECTORS

4.4.1 Recruitment and Training

Inspectors are recruited based on ability to deal with the public and present a good image, maturity, and report writing ability. No previous experience in law enforcement is sought, but military or municpal public service is considered desirable, as is the ability to speak Spanish. Of the five current inspectors all speak at least sufficient Spanish to get by on the job. Prospective fare inspectors must also: have at least a high school education; be bondable; satisfactorily complete physical, psychological and polygraph exams; have no criminal record; and pass a personal background investigation.

Training a new inspector takes five weeks, including classroom time and supervised on-the-job training. Classroom training includes:

- Legal authority or an inspector
- Judicial process of citations
- Public relations
- Report/citation writing and arrest procedures
- Court testifying
- All aspects of fare inspection using the self-service fare collection manual
- Company policy and procedure
- Use of mace for self-protection
- First aid and CPR.

After completion of classroom subjects, each new inspector works on the line with a training officer for two to three weeks.

The inspector's progress is monitored closely by the inspection supervisor before he or she is allowed to work alone. Progress is evaluated based on knowledge of stations, sectors, jurisdictional lines, ease in dealing with the public, handling of everyday problems, understanding the limited authority associated with the position, and ability to enforce MTDB's ordinances with a pleasant personality. Overly-officious behavior is discouraged.

Other areas that are stressed during on-the-job training include proper use of two-way radios, working closely with other law enforcement agencies, and when to call for assistance or backup of the contract security force. Since a good portion of their time is spent on public relations, new inspectors are encouraged to talk with patrons and offer assistance when necessary under the direction of the field training officer. All written material submitted by the inspectors is reviewed by the inspection supervisor and returned for rewriting when necessary. The importance of accuracy and neatness is stressed. Inspectors are made aware of the fact that reports become permanent records, not just at MTDB, but at courts, and other agencies as well. All the inspectors described the training as good, adequate or excellent.

4.4.2 Attitudes and Opinions

The inspectors all feel that most passengers do not mind being inspected or are even happy to see an inspector. However, the few uncooperative passengers can make the inspector's job difficult. Two of the inspectors remarked that they were surprised that so few passengers try to cheat the system. All the inspectors seem to feel that the $20 fine is about right and that reducing the level of inspection would result in higher levels of fare evasion. The inspectors tended to minimize the degree of physical danger in their job but noted that some amount of physical danger is often present, primarily from uncooperative fare evaders. Three of the five inspectors interviewed noted that military passengers are more likely to be

uncooperative than others. Passengers failing to give proper identification was noted as a frequent problem by three inspectors, and fare evaders running away (either before or after contact with the inspector) by two inspectors.

4.4.3 Changes Desired

Four inspectors felt that more security officers would be desirable so that an officer could arrive more quickly when requested. One inspector suggested assigning the security officers to fixed sectors, as is the case with the inspectors. Three inspectors suggested some form of short-distance or zone fare, in addition to the Centre City fare, which they felt would reduce the level of fare evasion. Three inspectors made suggestions relating to the need for a dollar in exact change to buy a ticket - either more change machines, better maintenance of the change machines, or ticket machines that accept paper money.

4.4.4 Duties in Addition to Fare Inspection

In addition to fare inspection, the inspectors give information to passengers, report problems other than fare evasion, write citations for violations of MTDB's parking ordinance, and conduct passenger counts. Inspectors have ready information on bus transfers and connecting routes, safety, and all other rules on board the train. They are expected to assist large groups, lost children, and the elderly and handicapped, and to deal with found property. Emergency first aid to injured parties has been limited to providing comfort and support to victims of falls and heart attacks, and one near-birth on board the train in the early days of operations. Although San Diego Trolley contract security provides roving patrols along the right-of-way, inspectors check stations when waiting for trains. Any act of malicious mischief, e.g., tampering with equipment, graffiti, vandalism, etc., is reported immediately to the on-duty controller.

The inspectors report that providing information is a major part of their job. Some of the inspectors feel that reporting problems such as non-functioning fare machines and drunken passengers is an important part of the job, while others minimize its importance. Writing citations for parking violations in MTDB's lots is a duty added to the inspector's job in November 1982. One day each week, each inspector was assigned to spend an hour in the morning or evening patrolling the parking lots.

Each day the ticket inspectors conduct 12 passenger counts on runs designated in a sampling plan developed by the San Diego Association of Governments (SANDAG). These counts take precedence over ticket inspections. To do a count, an inspector boards a car and requests each passenger to show proof of payment, noting the totals by fare type on the form shown in Figure 4-9. Citations are issued after the count is complete. The results are used by SANDAG to estimate daily trolley riders using passes and transfers. These estimates are added to daily vendomat tallies of single-ride tickets, multi-ride validations and transfer upgrades to arrive at total daily ridership.

4.5 COST-EFFECTIVENESS

A question which often arises in consideration of SSFC is the proper balance of enforcement and fare evasion. How much money should be invested to bring losses due to fare evasion to acceptable levles?

4.5.1 Actual Costs in San Diego

As estimated in Section 6.1.3, the total annual cost of the enforcement system is about $186,000. Since the trolley's annual ridership is about 4.1 million, it costs about 4.5 cents per passenger to enforce SSFC at current inspection levels. Annual fine revenue is about $21,200 (See Section 6.1.4), compared to fare evasion losses of $19,500, producing a net gain of $1,700 per year. This small difference does not appreciably reduce the net annual enforcement cost per passenger.

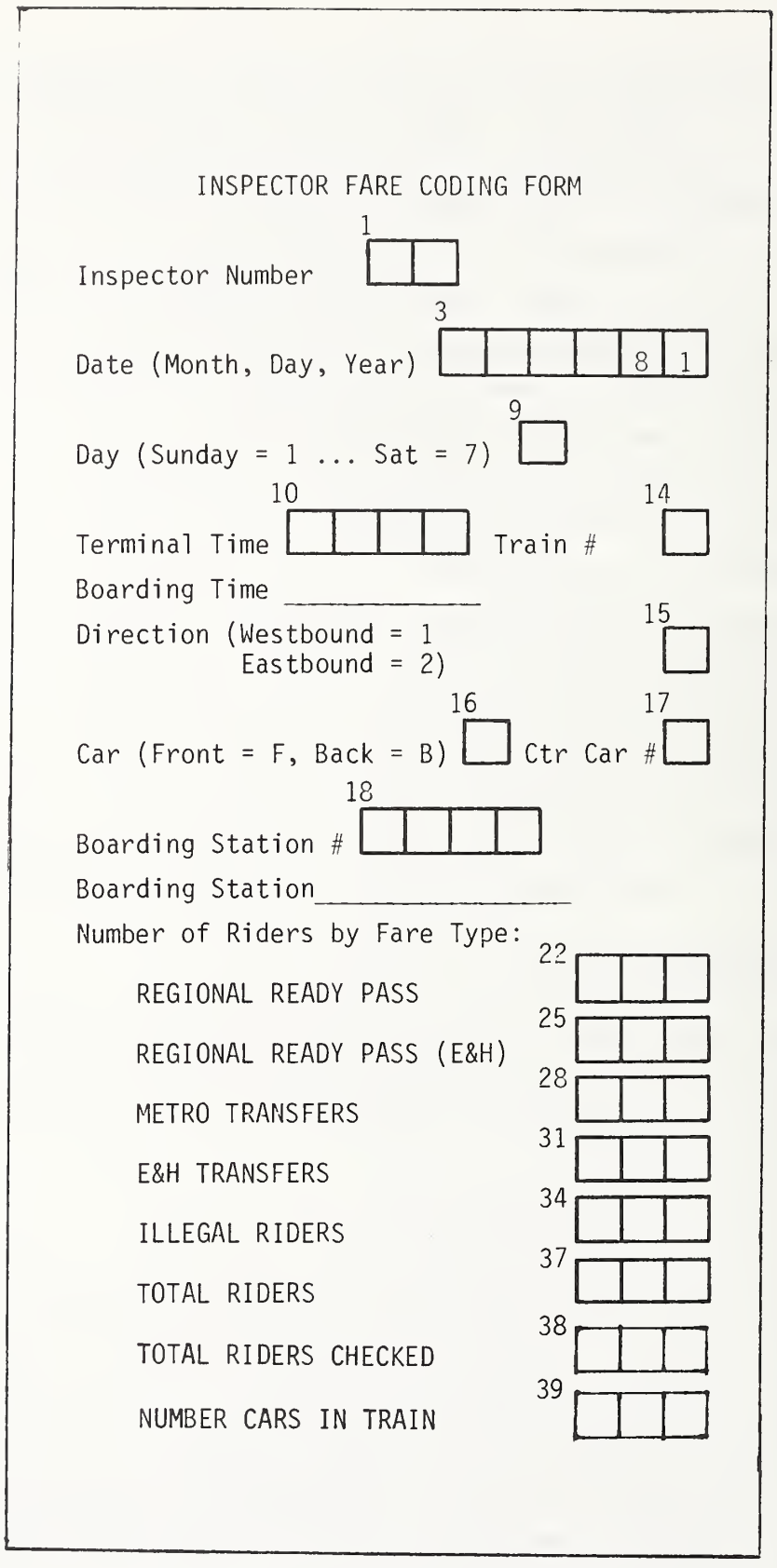


FIGURE 4-9. INSPECTOR FARE CODING FORM

4.5.2 Optimal Inspection Level

The Trolley's annual ridership of 4.1 million, combined with the measured fare evasion rate of 0.5% and an average lost fare per violation of $.96 (See Section 6.1.3), imply that the Trolley loses about $19,500 annually to fare evasion. That the losses to fare evasion are so much less than the cost of inspection, suggests that inspection levels could be reduced considerably before increased revenue losses cancelled out the cost savings. There may be very strong reasons for keeping inspection levels higher than the "theoretically optimal" level, defined in terms of cost effectiveness. Such reasons might include public relations, maintaining a particular image, and security. However, the figures from the Trolley's experience provide a valuable opportunity to illustrate the concept of an optimal enforcement level.

As an example, suppose that there were two inspectors on duty most days instead of four. Table 4-1 summarizes a calculation of net enforcement costs at the two staffing levels using

TABLE 4-1. COST OF ENFORCEMENT
PLUS REVENUE LOSS AT TWO INSPECTION LEVELS

	4 Inspectors/Day (Actual)	2 Inspectors/Day (Estimated)
Supervision*	$ 32,284	$ 32,284
Other*	154,238	77,119
Total Enforcement	186,522	109,403
Fine Revenue	(21,200)	(15,900)
Net Enforcement	165,322	93,503
Revenue Loss	19,500	39,000
	$ 184,822	$ 132,503

*Includes annualized capital cost for radios

cost figures from Chapter 6. Assuming that costs other than supervision are proportional to the number of inspectors, the

total annual cost would be reduced from $186,522 to $109,403. As a conservative assumption, suppose that the fare evasion rate doubles in response to halving the inspection rate, resulting in an annual revenue loss of $39,000. Revenue from fines might remain constant. Since each inspector would encounter twice the number of fare evaders as now, two inspectors might write about the same number of citations as four do now. If each inspector wrote the same number of citations per day as now, fine revenue would fall in proportion to the number of inspectors, but that seems unlikely if the evasion rate actually rose. As a compromise, assume that fine revenue drops by 25%. The result is that net enforcement cost, plus lost fare revenue would drop approximately $50,000 or 28%.

Using the same logic, it can be shown that the net cost would continue to drop until the number of inspectors per day was about 1.5 with a fare evasion rate of 1.3%.* For practical reasons, however, it seems unlikely that one would want fewer than two inspectors per day, so that at least one inspector is present on the line at all times.

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*Set net enforcement cost plus revenue loss equal to $32,284 + 154,238(x/4) + 19,500(4/x) - 21,200(1/2 + x/8), where x = number of inspectors and the final term is an average between 21,200 (constant revenue) and 21,200(x/4) (revenue proportional to the inspection level). The derivative with respect to x is $35,910 - 78,000(1/x^2)$, which, when set equal to zero, yields a minimum at x = 1.47.

5. PASSENGER ATTITUDES

An on-board survey of passengers was conducted in August 1982 to explore passengers' attitudes concerning SSFC. The survey was self-administered. Employees of the San Diego Association of Governments (SANDAG) handed out and collected the survey forms (see Appendix B for copies of the forms) and were available to answer riders' questions. The forms were handed out between 6 AM and 8 PM on August 3, 4, and 5 (a Tuesday, Wednesday and Thursday) and 10 AM and 6 PM on August 7 and 8 (a Saturday and Sunday) on a different one of the ten cars in base period service each day. A total of 3690 riders, or approximately 68% of all riders on-board, returned at least a partially completed form.*

The survey form was bi-lingual, with the questions appearing in English on one side and Spanish on the other side. Minor differences in the wording of the questions may have had a slight effect on the survey results. There were also four different versions of the questionnaires, with some questions included on one or more versions and not on the others. The version given to the rider depended on which of the four fare payment methods they used (single-ride ticket, 10-ride ticket, transfer or monthly pass).

The data from the survey have been divided into two groups. Those respondents who checked "Only a few times a year," or "This is the first time I have used the trolley" in response to the question "In a typical week, how many times do you board the trolley?" have been included in the infrequent or first-time

*The actual response rate is somewhat higher as some passengers may have been on more than one car which was surveyed. Although cars were chosen with varied terminal times to minimize this problem, the number of passengers riding more than one surveyed cars may have been quite large as is indicated by a drop from 93% on the first day to 45% on the final day of the survey in the percent of riders completing the form.

rider category. Those riders giving one of the other two possible responses, "less than once a week" or specifying the number of times per week, have been included in the repeat rider category. The data from the latter category have been weighted in inverse proportion to their reported trip frequency in order to reflect the probability of being included in the sample. Whenever the characteristics of the repeat riders per se, rather than those of their trips, are described in this chapter, the weighted data have been used. This was done in order to draw conclusions about a "population of users" rather than merely those persons using the trolley at any given time.

5.1 UNDERSTANDABILITY

The degree of understanding needed to use the system will vary depending on the passenger and the trip or trips they wish to make. A tourist who wants to use the trolley to go to the border only needs to understand how to use the ticket machine and to retain the ticket once on board. Advance knowledge of the checking system is necessary only to deter potential fare evaders and speed up the checking process. Only frequent users are likely to be interested in 10-ride tickets or monthly passes. This considerably reduces the amount of information that one-time users must assimilate before boarding the trolley.

5.1.1 Repeat Riders*

Most repeat riders (89%) found the instructions at the stops and on the machines easy to follow. Only 10% of the riders felt that a disadvantage of SSFC was that it is harder to understand.

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*This section includes those riders who reported a trolley trip frequency of higher than a few trips per year. The results from those riders making their first trip or having a trip frequency of only a few times a year are reported in the following section.

However, substantially larger percentages did not understand various aspects of the system. Fifty-seven percent of the non-transfer repeat riders did not know how to pay when transferring, and 58% of all repeat riders did not know whether tickets are collected or not. Lack of knowledge about transferring among non-transferring passengers may not be untypical for transfers between separate rail and bus systems. Lack of knowledge about ticket collection may indicate that passengers need not understand the fine points of the system to find it usable. However, the lack of understanding may reduce the flexibility of the system for many riders. Of the repeat riders using single tickets or transfers, 43% reported being unaware of the monthly passes and 10-ride tickets.

The most common source of information about the fare payment system was the instructions at the stations, which provided information for 58% of the repeat riders. The next most common sources of information were trolley employees (11%) and other people (26%). Brochures and newpaper ads or articles each provided information for 5% of the repeat riders.

5.1.2 Infrequent and First-Time Riders

A concern from the start of the project was whether the fare collection system would present special problems for infrequent and first-time riders, who made 37% of the trips. This concern was especially great for the trolley since it serves many visitors and tourists going to or coming from the Mexican border (29% of the trips were made by visitors or tourists who comprised 56% of the infrequent and first-time riders). As seen in Table 5-1, infrequent and first-time riders had little problem understanding the instructions at the stations. They did, however, rely slightly more on having the system explained to them by a Trolley employee or other person than did the other riders. Infrequent and first-time riders also had very little understanding

TABLE 5-1. UNDERSTANDABILITY vs. FREQUENCY OF USE

	Repeat Riders[1] (n=1930)	Infrequent & First-Time Riders (n=1135)
How did you learn how the fare payment system on the trolley works? (multiple responses allowed--percents of all questionnaires returned)		
Reading the instructions at the station	56%	47%
Brochure or handout	5	2
Article or ad in newspaper	5	4
A trolley employee explained it	11	15
Someone else explained it	25	32
Do you agree that: (percents of those responding)		
The instructions at the station on how to pay are clear?[2]	89	85
The instructions on the ticket machines are easy to follow?[3]	90	90
Checked harder to understand as a disadvantage of self-service fare payment (percents of all questionnaires returned)	10	14
Do you know: (percents of those responding)		
How the trolley checks to see if passengers have paid their fare?	72	35
That you can buy monthly passes or 10-ride tickets?[4]	57	34
Whether tickets are collected?	58	31
The penalty for not paying the fare?	53	21
How to pay your fare when transferring between a bus and the trolley?[5]	57	17
Where to buy monthly passes or 10-ride tickets?[4]	34	17

[1] The responses for repeat riders have been weighted in inverse proportion to their trip frequency

[2] Only single fare and transfer passengers were asked this question (n=1356 and 654 respectively).

[3] Single fare, transfer and 10-ride ticket passengers were asked this question (1459 and 948 respectively).

[4] Only single fare and transfer passengers were asked these questions (1274 and 629).

[5] Only single fare and 10-ride ticket passengers were asked this question (n= 1347 and 938).

of the system beyond purchasing single-fare tickets. For example, only 35% of these riders knew how the trolley checks fares, only 21% knew the penalty for not paying the fare, and only 31% knew whether or not tickets are collected. While, as noted earlier, this knowledge is not necessary for first-time or occasional riders, uneasiness from a lack of understanding of the system may deter some potential users from making trips using the Trolley.

5.1.3 Spanish Speakers

The SSFC system does not appear to present particular problems for Spanish-speaking persons, who comprise a large portion of the San Diego area population. In fact, the respondents who filled out the Spanish version of the survey form, especially among infrequent and first-time riders, reported having a better understanding of the SSFC system than did those who filled out the English version. As shown in Table 5-2, a higher percentage of the Spanish-speaking respondents among both repeat riders and infrequent and first-time riders felt that the instructions at the station were clear. The Spanish-speaking infrequent and first-time riders were also more likely to know about the 10-ride and monthly passes. Spanish-speaking repeat riders were, however, less likely to know about the 10-ride tickets and monthly passes than their English-speaking counterparts. Only 4% of the Spanish-speaking repeat Trolley riders used 10-ride tickets and only 2% used monthly passes (compared to 12% and 6% respectively of English-speaking repeat riders). This may indicate that the Spanish speakers did not have a great deal of use for the multi-ride tickets, or that purchasing these tickets was relatively inconvenient for them. In any event, it is evident that there is no great language barrier to use of the Trolley by Spanish-speaking people.

TABLE 5-2. UNDERSTANDABILITY VS. LANGUAGE

	Repeat Riders[1]		Infrequent and First-Time Riders	
	Spanish (n=364)	English (n=1566)	Spanish (n=77)	English (n=1058)
How did you learn how the fare payment system on the trolley works? (multiple responses allowed--percents are of all forms returned)				
Read the instructions at the station	46%	58%	38%	48%
Brochure or handout	9	4	3	2
Article or ad in newspaper	5	5	3	4
A trolley employee	14	10	16	15
Someone else	28	24	39	31
Do you agree that: (percents of those responding)				
The instructions at the station on how to pay are clear?[2]	94	88	87	85
The instructions on the ticket machines are easy to follow?[3]	92	90	87	90
Checked harder to understand as a disadvantage of self-service fare payment: (percents are of all forms returned)	4	7	13	9
Do you know: (percents are of those responding)				
How the trolley checks to see if passengers have paid their fare?	79	71	54	34
That you can buy monthly passes or 10-ride tickets?[4]	49	58	41	33
Whether tickets are collected?	34	61	39	31
The penalty for not paying the fare?	62	52	39	21
How to pay fare when transferring between a bus and the trolley?[5]	61	57	43	16
Where to buy monthly passes or 10-ride tickets?[4]	34	34	25	16

[1] The responses for repeat riders have been weighted in inverse proportion to their trip frequency.

[2] Only single fare and transfer passengers were asked this question (n=231, 1126, 54 and 600).

[3] Single fare, transfer and 10-ride ticket passengers were asked these question (n=221, 1237, 54, and 894).

[4] Only single fare and transfer passengers were asked these questions (n=183, 1104, 44 and 585).

[5] Single fare and 10-ride ticket passengers were asked this question (n=179, 1095, 48 and 581).

5.2 ENFORCEMENT*

The survey asked for riders' opinions about the enforcement system. In evaluating the results of the survey, the limited understanding of the enforcement system held by many riders should be considered. However, the number of users of the system who did not understand the enforcement, coupled with the low evasion rate (see Section 4.3), itself indicates that the system is effective without being overly obtrusive.

As shown in Table 5-3, few riders felt that having to hold on to their ticket during the ride was a disadvantage of the system. The actual checking of tickets was a problem for a slightly higher percentage of people (8% of the respondents were embarassed by the checking and 21% were annoyed). Spanish-speaking repeat riders were more likely to check these problems (16% and 33% respectively). The problems with riders' reactions to checking did not appear to be caused to a large degree by the inspectors, as only 6% of the respondents felt the inspectors were rude, and 62% felt they were courteous. Furthermore, although Spanish-speaking people were more likely to respond that inspectors were rude (9% checked this response), they were also more likely to feel the inspectors were courteous (74% gave this response). In general, only 14% of the repeat riders felt that being inspected was a disadvantage of the system.

Most repeat riders did not feel that fare evasion was a major problem. Twenty-four percent of the riders responded that more people cheating was a disadvantage of SSFC while 20% felt fewer people cheating was an advantage. Riders with high incomes were more likely to feel that more people cheating was a disadvantage (34% of those with household incomes over $20,000 gave this response). Spanish-speaking people, as a group, felt

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*In this section the responses from the first-time and infrequent riders have been excluded because of the relatively low likelihood that they understand the enforcement system or have dealt with it.

TABLE 5-3. PASSENGER ATTITUDES CONCERNING ENFORCEMENT

Possible disadvantages of SSFC concerning enforcement	Percent repeat riders (n=1930) checking as a disadvantage
More people cheat	24%
Don't like being inspected	14
Need to hold your ticket during the ride	10

	Percent repeat riders checking response		
	Too high	Too low	Just right
The $20 fine is: (n=1774)	29%	17%	54%
	Courteous	Rude	OK
The inspectors are: (n=1760)	62%	6%	32%
	Embarrassing	Annoying	No problem
Being asked to show proof of payment is: (n=1765)	8%	21%	71%
	More often	Less often	Same as now
Passengers' tickets should be checked: (n=1711)	45%	11%	44%
	Hardly any	A few	Too many
The number of passengers who get away with riding for free is: (n=1522)	26%	52%	22%

fewer people cheated under this system: 25% listed fewer people cheating as an advantage and only 10% listed more people cheating as a disadvantage. Also, 33% of the Spanish speakers felt that hardly any people were cheating under this system (compared to only 24% of the English speakers). However, 30% of the Spanish-speaking riders felt that too many people were riding free, while only 20% of the English-speaking riders gave this response. Despite the relatively small percentages of riders listing cheating as a disadvantage and the high percentage of trips that are already being checked, 45% of the riders felt that passengers' tickets should be checked more often, while only 11% responded less often.

More repeat riders felt that the $20 fine for not paying the fare was too high (29%) than felt it was too low (17%). Those with household incomes under $5,000 were more likely to say the fine was too high (38%), and less likely to say it was too low (13%).

5.3 EASE OF USE*

Most riders had few problems with day-to-day use of the system. Ninety-three percent of the repeat riders agreed with the statement "The ticket machines are easy to use" (see Table 5-4). The greatest problem appears to be having $1.00 in change. Eighty-nine percent of the riders using single-fare tickets or transfers agree that more change machines are needed. Buying passes is also more difficult than many passengers would like. Eighty-two percent of those riders using monthly passes and those riders using 10-ride tickets agreed that their type of ticket should be sold at more locations. Riders making trips to work or school were more likely to agree that 10-ride tickets should be sold at more locations (90% compared to 77% of those making trips for other purposes). This pattern was not present for monthly pass users. Also, as mentioned previously, Spanish-

*In this section, as in the previous one, only responses from repeat riders have been included due to the lack of familiarity with the system of most infrequent or first-time riders.

TABLE 5-4. PASSENGER OPINIONS ON EASE OF USE

	Percent of repeat riders responding who agree with the statement
Ticket machines are easy to use (n=1613)	93%
There should be more change machines (n=1407)[1]	87
There should be more places to buy Ready-10 tickets (n=153)[2]	82
There should be more places to buy monthly passes (n=76)[3]	80

Possible advantages of SSFC	Percent repeat riders (n=1930) checking as an advantage
Faster boarding and exiting	71%
More convenient	43
Don't need to deal with driver	42
Fewer people cheat	20
Availability of Ready-10 tickets	19
Other advantages	5

Possible disadvantages of SSFC	Percent repeat riders (n=1930) checking as a disadvantage
More people cheat	24%
Time to buy or validate ticket at the station	18%
Ticket machines often don't work	15
Don't like being inspected	14
Need to hold your ticket during the ride	10
No driver present on the second or third car	7
Harder to understand	7
Other disadvantages	2

	Percent repeat riders (n=1666) checking	
	Self-service	Conventional
Which fare collection system do you prefer to use?	84%	16%

[1]Only single fare and transfer passengers were asked this question.

[2]Only passengers using Ready-10 tickets were asked this question.

[3]Only passengers using monthly passes were asked this question.

speaking riders were more likely to feel that passes should be sold at more locations.

Of seven possible disadvantages of SSFC listed on the survey form, more people cheat was checked by the largest percentage of repeat riders (24%). Of the problems with ease of use, the time to buy or validate their ticket at the station was checked most often (by 18% of the repeat riders). Those making trips to school or work were somewhat more likely to check this disadvantage (24%). A relatively high percentage of the riders in these categories also checked the ticket machines often not working as a disadvantage (21% compared to 15% of all riders). These riders are likely to time their arrival at the stop more closely and also to consider arriving at their destination on time more important. Thus any delay at the stop would be more likely to cause them to miss their train and, additionally, a missed train would be more problematic for them.

Despite the disadvantage of buying single-fare tickets from the machines, they remain the most popular form of payment with 61% of the passengers surveyed using them to make their trip. Even among those riders using the trolley more than five times a week, only 45% of the trips were being made using 10-ride tickets or passes (30% of all trips are made using these forms of payment). Originally MTDB had hoped to minimize the use of single-fare tickets. As on transit systems with conventional fare collection, saving money, rather than simply convenience, appears to be the primary motive for purchase of pre-payment instruments. In support of this, 92% of pass users agreed with the statement, "It is cheaper for me to buy a pass than to buy a ticket for each ride." Only 36% of the trips were being made by passengers who reported using the trolley more than five times a week (the monthly pass is priced at 18 round trips), and only 46% of the trips were being made by passengers who use the trolley more than once a week. Consequently, while the use of passes and Ready 10 tickets may increase somewhat if, for example, their use by

Spanish-speaking people is encouraged, it appears unlikely that they will ever become the dominant form of payment.

Of the five possible advantages of SSFC listed on the survey form, the highest percentage of repeat riders (71%) checked faster boarding and exiting as an advantage of the SSFC system. Eighty-five percent of those with a household income of more than $30,000 felt that this was an advantage. More convenience was checked as an advantage by 53% of all repeat riders and 66% of those with household incomes over $30,000. No need to deal with the driver and the availability of 10-ride tickets were given as advantages by 42% and 19% of the respondents respectively. Those riding the trolley to work or school were most likely to consider availability of the 10-ride ticket as an advantage (28%).

Most riders seem to find the SSFC system quite usable, with 84% preferring it to the conventional fare collection system. Despite the apparent lack of special problems for Spanish-speaking people, only 67% of those filling out the Spanish version of the survey form preferred SSFC to conventional fare collection. Also, those who had used monthly passes before they began riding the trolley were slightly less likely to prefer the SSFC system than other riders (80% compared to 85%). In general, there were no unexpected problems with use of the system and most riders seem quite comfortable with it.

6. COST

Costs of SSFC have been estimated under four categories: capital costs, annual operating cost for fare collection, annual enforcement cost, and annual revenue loss. Total annual cost was then computed by annualizing the capital cost. For comparison purposes annual costs have been estimated assuming the trolley used conventional, on-board fare collection. The cost savings from having chosen SSFC were then computed.

6.1 COST OF SSFC

6.1.1 Capital Cost

The major capital cost is for the 34 ticket machines. In Chapter 2, the total purchase price was reported as $567,971 for the first 28 machines, and $114,275 for six more machines, excluding tax. Adding the 6% California sales tax, and excluding $7,568 plus tax out of the purchase price which paid for consumables, the total capital outlay for ticket machines was $715,156. Four change machines cost $10,500 including tax. In addition, SDTI purchased a specially-equipped van for use in collecting cash from the ticket machines, at a cost of approximately $8,500. Another van or truck is in use for maintaining the ticket machines. The five ticket inspectors and the supervisor of inspection communicate via portable radios which cost

$1,000 each.* Total capital costs for SSFC are then approximately $749,000:

34 Ticket Machines	$715,200
4 Change Machines	10,500
2 Trucks/Vans	17,000
6 Radios	6,000
	$748,700

6.1.2 Annual Operating Costs

Annual operating costs include cash collection from the ticket machines, maintenance of the ticket machines, operating costs for service vehicles, supplies for the ticket machines, and rent on telephone lines connecting the ticket machines to central control. Cash collection and processing requires two and a quarter full-time revenue processors, who are employees of SDTI, and a member of SDTI's contract security force. Total annual cash collection costs, including overhead, have been estimated by SDTI as:**

Revenue processors	$ 39,000
Security	20,000
Operating cost of cash collection van	6,500
Total	$ 65,500

Maintenance costs include labor, and operation of one truck or van. Labor includes the maintenance supervisor, who estimates that he spends 35% of his time on ticket machines, two linemen who together spend 140% of full-time on maintaining the machines, and an electronics technician, who was spending all of his time on the ticket machines in late 1982, although his level of effort was expected to decrease. Total labor costs are approximately $63,000 per year, including overhead. Spare parts for fiscal year 1982 were budgeted at $4,000. The operating cost of the truck of van is estimated at $6,500, bringing the total annual maintenance cost to $73,500.

*The radios were bought by SDTI as part of a large purchase. Many Trolley employees use such radios, all of which communicate via the same base station. In units of one, the radios would cost $2,800.

**The figures might seem low; however, note that SDTI does not count the revenue. Instead the bank's count is compared to the count produced automatically by the ticket machines.

Supplies for the ticket machines include ticket stock, ink ribbon, and spare parts. When the ticket machines were purchased, MTDB bought a six-month supply of ticket stock for $7,167 and a six-month supply of ink ribbons for $622. Together these imply an annual cost for consumables of $15,600.

The ticket machines are connected to central control via telephone lines which SDTI rents for $943.71 per month or about $11,300 annually.

6.1.3 Enforcement Costs

Enforcement costs include five full-time ticket inspectors, a full-time supervisor of ticket inspection, and miscellaneous items such as uniforms and ticket books. There are also costs for clerical services, especially data entry, and a small amount of computer time, which are not charged to the fare inspection account, but rather included in overhead. MTDB bills SDTI quarterly for its fare collection services. For the year ending September 1982, the totals were:

Labor	$ 95,221
Allocated Overhead	82,554
Expenses	7,961
TOTAL	$185,736

In principle some costs borne by the court system should be charged to enforcement. There is no simple way to estimate those costs. The courts retain 15% of all fines paid, and it has been assumed that this revenue pays for the court's expenses. SDTI's contract security force occasionally assists in detaining fare evaders. However, it is unlikely that security costs are any higher than they would be without SSFC. Therefore, no costs have been included for security.

6.1.4 Revenue Losses and Gains

The Trolley's 1982 estimated ridership was 4,060,030, while the fare evasion rate was measured at 0.5%, which implies a total of 20,300 lost fares. Using the distribution of fare

evasion types given in Section 4.3.2, MTDB has estimated the average lost revenue per violation at $.96. The calculation makes the conservative assumption that no lost fares are Centre City fares (at $.25) or elderly or handicapped fares (at $.40). All lost fares are calculated as full-fares (at $1.00). The annual estimated revenue loss is then $19,500.

On the other side, MTDB receives 85% of revenue from fines collected by the courts. For the first eight months of 1982 MTDB received an average of $1,769 per month from the courts, which is equivalent to an annual rate of $21,200. On balance then, the fine revenue compensates for fare evasion losses, producing a small net gain of about $1,700 annually.

6.1.5 Total Annual Cost of SSFC

To compute total annual cost the capital cost from Section 6.1.1 must be annualized and added to the various annual costs from Section 6.1.2 through 6.1.4. MTDB uses a 20-year economic life for the ticket machines and change machines, a 2.5-year life for vans and trucks, and a 15-year life for the inspectors' radios. Assuming a discount rate of 10% per year produces a total annualized capital cost of $93,700 as shown in Table 6-1.

TABLE 6-1. ANNUALIZED CAPITAL COST

Item	Estimated Economic Life	Capital Recovery Factor with 10% Discount Rate	Capital Cost	Annualized Cost
Ticket Machines	20 years	.117	$715,200	$83,700
Change Machines	20	.117	10,500	1,200
Vans/Trucks	2.5	.472	17,000	8,000
Radios	15	.131	6,000	800
				$93,700

Total annual cost as shown in Table 6-2 is then $443,600, or about $.11 per passenger.

TABLE 6-2. TOTAL ANNUAL COST OF SSFC

Annualized capital		$ 93,700
Operating		
Revenue processing	$ 65,500	
Maintenance	73,500	
Supplies	15,600	
Telephone	11,300	165,900
Enforcement		
Inspection	185,700	
Revenue loss*	(1,700)	184,000
TOTAL		$443,600

*Net gain, including fine revenue

6.2 COMPARISON WITH CONVENTIONAL FARE COLLECTION

The San Diego Trolley has never operated under conventional fare collection. Moreover, it was more or less always assumed during the planning of the system that some form of SSFC would be used. Nevertheless, it is possible to develop estimates of the cost for conventional fare collection, sufficient to give a feel for the differences in costs. The Trolley could, conceivably have been built with barrier-separated, fare-paid areas, and off-board fare collection. A more likely alternative, which is more common in North American light rail operations, is on-board fare collection supervised by the drivers. Thus on-board fare collection is the method for which costs are developed in this section.

6.2.1 Capital Costs

Capital costs would include car modifications, fareboxes, and central cash processing equipment. The 14 light rail vehicles used for the present service would have to have been bought with a different configuration, placing the driver in the traffic pattern as passengers board. Based on a conversation with a

representative of the supplier of the Trolley's vehicles, Siemens AG, such a modified configuration would probably add $2,000 to $3,000 to the price of each car. A figure of $2,000 has been used to avoid biasing the calculations in favor of SSFC.

Estimates for fareboxes and related equipment were obtained from a consultant specializing in fare collection, who is under contract to MTDB.* Electronic, registering fareboxes would cost about $4,000 per vehicle; spare cash vaults would cost another $500 per vehicle. Central cash processing equipment would cost about $35,000. Total capital cost would then be:

Modifications to 14 cars	$28,000
14 Fareboxes	56,000
14 Spare vaults	7,000
Central cash processing	35,000
Total	$126,000

6.2.2 Operating Costs

Operating costs would include extra drivers to collect fares on all multi-car trains, maintenance on the fare collection equipment, and fare evasion losses.

About 10% of the trolley runs have three-car trains; the remainder are two-car trains. If each car had a driver to collect fares, the total paid driver time would increase by 110%. The present schedule uses 817 hours of paid driver time per week at an average wage of $10.12. With SDTI's 26% for fringe benefits and payroll taxes, the total cost for extra drivers would be $11,460 per week or about $596,000 per year.

Maintenance on the fareboxes has been figured at 10% of the purchase price. This compares to the ticket machines, whose

*Conversation with J. Wesley Leas of Bryn Mawr PA, January 5, 1983.

maintenance cost is 9% of their purchase price. The difference reflects the moving environment in which the fareboxes would operate. Maintenance on the central cash processing equipment has been figured at 5% of the purchase price to reflect its protected, stationary operating environment. Total maintenance cost would then be:

Fareboxes (10% of $63,000)	$6300
Central Cash Processing (5 % of $35,000)	1750
Total Maintenance	$8050

To complete the estimate, a figure for fare evasion losses is needed. Since drivers would often be more concerned with driving than monitoring fare payment, it is possible that the fare evasion rate with on-board fare collection would be higher than the current 0.5%. For the sake of conservatism, revenue losses have been assumed to remain at their present level of about $19,500 per year.

6.2.3 Total Annualized Cost

Before totalling all the costs, the capital costs must be annualized. The following economic lifetimes have been assumed: car modifications - 50 years; fareboxes - 15 years; and central cash processing equipment - 20 years. With a discount rate of 10%, capital recovery factors are .101, .131 and .117 respectively. The annualized capital cost is then:

Car modifications	$2,800
Fareboxes with vaults	8,300
Central cash processing	4,100
Total	$15,200

Using this figure a total annualized cost for conventional fare collection can be computed:

Annualized capital	$ 15,200
Extra drivers	596,000
Maintenance	8,100
Fare evasion losses	19,500
Total	$638,800

6.2.4 Cost Savings Due to SSFC

Conventional, on-board fare-collection appears to be more expensive than SSFC by about $195,000 per year. Capital costs are much less for conventional fare collection, but operating costs, primarily for extra drivers, are much greater. It is possible that the cost of fare collection on second and third cars of multi-car trains could be reduced by using personnel other than drivers, at a lower wage rate. Experience in other transit agencies argues against this. If it were possible, however, to use conductors, at a rate similar to that of the current ticket inspectors, the total annual cost of conventional fare collection would be reduced by around $190,000. Using conductors at this rate would nearly eliminate, much of the cost advantage of SSFC.

On the other hand, there are factors which could increase the cost advantage of SSFC. If the fare evasion rate were higher with conventional fare collection, the cost advantage would increase. For example, a fare evasion rate of 5% would add $166,000 to the cost advantage of SSFC. It is also possible that SDTI would incur additional costs for counting fare receipts. Currently, the ticket machines produce a very accurate count. Registering fareboxes, however, are not so accurate, so SDTI might have to invest in additional equipment and labor to count money. Finally, as shown in Section 3.2.7, SSFC may produce a savings in vehicle requirements of 12% to 14%, which would produce a substantial cost advantage to SSFC.

7. CONCLUSIONS AND TRANSFERABILITY

7.1 FEASIBILITY

The Trolley's experience shows clearly that SSFC is workable in at least one U.S. transit environment. The staff of MTDB and SDTI have very positive attitudes toward the SSFC system. To be more specific, the system which has been shown feasible includes:

1. Wayside vending and validation at stations and stops.
2. High inspection levels.
3. Enforcement by a special force of inspectors with limited police powers to issue citations which are processed by the court system.

The transit environment in which this system proved feasible also includes some notable features:

1. Relatively few, widely-spaced stations and stops.
2. A special image as a new, clean, modern transit system.
3. Significant levels of tourist usage, especially in the summer.
4. A mild winter which is without snow, ice or extreme cold, but does have heavy, driving rain storms.

7.2 EQUIPMENT

MTDB was able to procure equipment from a foreign supplier which has proven very reliable, in the view of MTDB and SDTI staff. SDTI's maintenance staff has been able to keep the vending machines operating with a high degree of availability, such that passengers are rarely unable to buy or validate a ticket. This degree of reliability has been achieved at a cost

that does not negate the cost advantages of SSFC. The validators, which are of conventional, electromechanical design, have been less reliable, measured in terms of transactions between failures, than the ticket dispensers, which are of advanced, solid-state design. An important class of maintenance problems, which SDTI staff has had to overcome, consists not of mechanical problems, but rather of things such as obtaining good-quality ticket stock, and establishing schedules for replenishing ticket stock and removing full cash vaults.

7.3 TRANSIT OPERATIONS

SSFC does speed the boarding and deboarding process compared to on-board fare collection by drivers. Each additional boarding passenger takes only about a fourth as much time under SSFC, using multiple doors, as under one-door, on-board fare collection. Deboardings take only about a third as much time under SSFC. Differences in observational methods in San Diego and Boston leave doubt about the effect of door operating time under the two systems. The San Diego Trolley's passenger-actuated door opening system seems to require about eight seconds per stop. It is possible that less time would be required for driver-operated door opening. In that case, SSFC could be slower when very few passengers board or alight, and faster when many passengers board or alight.

It was not possible to determine what productivity increases can be attributed to SSFC at the Trolley's scale of operations. The analysis shows a savings of 12% to 14% in vehicle travel times per run. In larger systems this savings might be translatable into savings in vehicle requirements of similar magnitude.

Regarding the potential for more flexible fare structures under SSFC, the Trolley's experience provides little evidence.

The Trolley's fare structure is not especially complicated and has not been significantly modified since operations began.*

A minor drawback of SSFC shown by the San Diego experience concerns coordination with other operators. The inability to collect transfers under SSFC in order to provide an accurate count of transfer passengers has required use of a transfer upgrade ticket for those transferring from local buses. Many passengers find the use of the upgrade ticket confusing.

Security in cash collection has not, so far, been a problem. The system does require collection of coin vaults from widely-separated stops from one to three times daily depending on the stop. There is no security problem in distributing ticket stock, as blank ticket stock is considered worthless.

7.4 ENFORCEMENT

Fare evasion levels are very low (0.5%) at the Trolley's high level of inspection (33% to 44% each month). MTDB has been able to recruit and train an effective team of inspectors at wages substantially lower than those paid for train operators. The inspection level could probably be reduced by at least half before increased losses from evasion cancelled out cost savings from reduced inspection labor requirements. The Trolley's experience shows that use of court citations in enforcement is workable, acceptable to passengers, and not a burden on the court system. Most cited passengers pay their fines, although many do so only after taking the case to court (in which case they usually pay a reduced fine) or after receiving a notice of a warrant. Only 21% of cases which go to court get dismissed. The ticket inspectors feel that they can distinguish valid excuses from simple attempts to evade the system, and they use this discretion in issuing citations, especially in dealing with

*In early 1984, MTDB annnounced plans for a zone fare structure. These plans had not yet been implemented and so could not be evaluated when this report was completed.

tourists and other non-residents who do not have proper proof of payment.

7.5 PASSENGER ATTITUDES

Passengers understand SSFC sufficiently to use it for the trips they make. Many passengers do not understand features they do not use, such as transferring and multi-ride tickets. Many passengers do not understand the details of the enforcement system, particularly the penalty for fare evasion. A majority of first-time riders, such as tourists and out-of-town riders do not understand the enforcement system. However, nearly 90% of all passengers, including first-time riders, regard the instructions on paying and using the ticket machines as clear. Spanish speakers do not have any special problems in understanding the system.

Most passengers have a positive attitude toward SSFC, stating they prefer it to conventional fare collection and believe it is faster and more convenient. Few passengers feel there is excessive cheating, that the fine is too high, or that inspections are annoying. A disadvantage of SSFC noted by a few single-ride and multi-ride ticket users is that one must allow time to buy or validate a ticket at the Trolley station.

MTDB had hoped to convince a majority of riders to use some form of prepayment. But, despite the inconvenience just noted, most passengers continue to use single-fare tickets, implying that SSFC does not provide any additional incentive to use pre-payment.

7.6 COST

Compared to conventional, on-board fare collection, SSFC has lower operating costs and higher capital costs. Much of the savings in operating cost comes from the use of inspectors at wages substantially below those that would probably be paid to

extra operators on the second and third cars of trains. Capital costs under SSFC are mainly for the wayside vending machines. There may be additional cost savings under SSFC due to lower fare evasion rates than under conventional fare collection and savings in vehicle requirements, although neither of these could be documented in San Diego.

7.7 TRANSFERABILITY

The San Diego Trolley's experience clearly establishes the workability of one form of SSFC in an American setting. However, there are several considerations to bear in mind before applying the Trolley's experience to another transit operation. Regarding the equipment used, MTDB had a freer hand in procurement, than would normally be the case, because no Federal funds were used. Using Federal funds, another agency might have more difficulty buying from a foreign supplier such as Autelca. Also, the Trolley's SSFC system relies entirely on wayside ticket vending and cancellation. In a system with many more stops, such as most bus systems for example, it would probably be necessary to use some form of on-board vending or validation. No conclusions about on-board equipment can be drawn from San Diego's experience.

There are several factors which may influence the Trolley's low fare evasion rate and success with enforcement. One is that wayside vending and cancellation makes it more difficult for fare evaders to avoid detection than would be the case with on-board equipment. The reason is that passengers cannot board, and then buy or cancel a ticket if they see an inspector. Another is that most stations are widely-spaced, so that an inspector usually has a chance to inspect nearly everyone on a car before a fare evader has an opportunity to get off the train. Finally, some observers have noted a particular atmosphere surrounding the Trolley, which affects passengers' attitudes toward it, and may reduce fare evasion. The Trolley is new, clean, modern in appearance, and offers a premium service. Staff believe that maintaining a

special image for the Trolley is important for maintaining favorable attitudes on the part of passengers and for keeping fare evasion levels low.

In the case of transit operations, some time savings were found, and there seems no reason to suppose that another operator would not have a similar experience. At the Trolley's scale of operation there might not be a difference in vehicle requirements between SSFC and conventional fare collection. For a larger operation, however, SSFC might very well yield substantial savings in vehicle requirements.

Finally the cost of SSFC, even assuming a very similar operation, could be different than in San Diego. Adjustment should be made for inflation and differences in wage rates between San Diego and other sites. Also, any significant difference in fare evasion rates, ridership, and average fare would affect costs.

APPENDIX A
DESCRIPTION OF BOARDING TIME MEASUREMENTS

In San Diego, employees of the San Diego Association of Governments (SANDAG) performed ride checks on 82 trolley trips over five days in mid-August 1982, including four weekdays and one Saturday. The weekday trips were spread approximately evenly over the whole operating schedule, from 5:50 AM to 9:00 PM. On Saturday, trips between 9:50 AM and 6:00 PM were checked. There were four observers on each two-car train, two on each car. Each observer counted the number of passengers getting on and off at each of the two doors (there are four doors on each car). In addition, each observer recorded one of four times as follows:

Car	Observer	Time Recorded
A	1	Time from first door open to last door closed on car A ("loading time")
	2	Total time train stopped ("dwell time")
B	1	Time from first door open to last door closed on car B ("loading time")
	2	Time one door open ("door time")

Passenger counts were recorded at all 18 stations. Times were recorded, to the nearest second, at all stations except the San Ysidro and Santa Fe stations at the ends of the line. Figure A-1 shows a copy of the form used. Observations were recorded at a total of 1,476 stops.

In Boston, checkers for the Massachusetts Bay Transportation Authority (MBTA) performed ride checks on two parts of the MBTA's light rail service known as the Green Line. The Riverside Line operates mostly on an above-ground, grade-separated right of way, going into a subway near downtown. The above-ground stations are all barrier-free. On inbound trips, at above-ground stations, passengers board and deboard through the front door of each one-car train, paying as they board. On outbound trips at above-ground stations, passengers

board and deboard through all three doors, without any fare payment. In the subway, passengers pay to enter a fare-paid area, and board and deboard through all three doors. The cars are Boeing/Vertol LRV's, which have wider-opening doors and more inside room for passenger movement than the PCC cars they replaced. The Riverside Line, in its above-ground portion, was chosen to be comparable to the non-downtown portion of the San Diego Trolley. Key points of similarity include: off-street loading and unloading at wide-spaced stations; an exclusive right of way with no stops for cross traffic; and modern equipment designed to facilitate passenger movements. The key point of difference, is that the Riverside Line uses on-board fare collection on inbound trips.

The Boston College Line is similar to the Riverside Line as regards fare payment and equipment. Its above-ground portion operates on a median-strip right of way, with stops for cross traffic. The passenger stops are more closely spaced than those on the Riverside Line, and are located on the median strip rather than off the street altogether. Subway operations on the two lines are similar.

The checkers worked in teams of three. On outbound trips, three checkers rode each car, each one recording the number of passengers getting on and off at one of the three doors and the number of seconds that door was open. On inbound trips, the checkers rode on three succeeding cars, one per car, recording the number of passengers getting on and off, the number of boarding passengers paying cash and the number of seconds the door was open ("loading time"). A total of 24 inbound trips and eight outbound trips were checked on the Riverside Line, and 28 inbound and nine outbound trips on the Boston Line.

The inbound limit of all checks was the third subway stop, Copley. On the outbound end, Riverside checks ended either at the 12th above-ground stop (Woodland) or the sixth above-ground stop (Reservoir); Boston College checks ended at either

the 18th above-ground stop (Wallingford/Chiswick) or the 10th above-ground stop (Harvard). The short checks accounted for about a third of those done. The checks were spread over three weekdays in July 1982, between 6:50 AM and 6:10 PM on the Riverside Line, and between 6:37 AM and 6:50 PM on the Boston College Line. Data were recorded at a total of 1,314 stops.

FIGURE A-1. FORM FOR SAN DIEGO BOARDING TIME STUDY

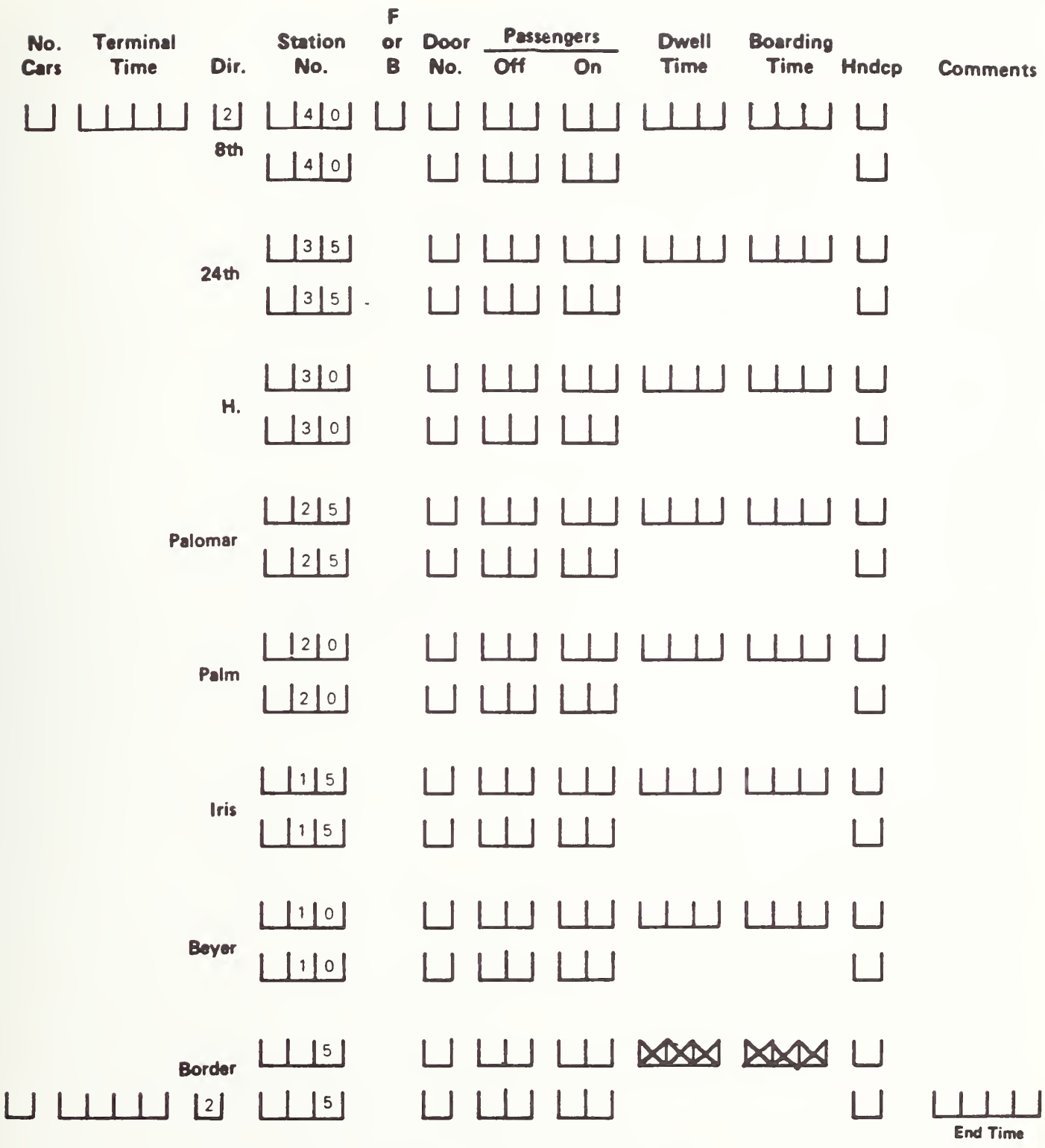

FIGURE A-1. Cont'd.

APPENDIX B

ON-BOARD SURVEY FORMS
(Reduced from 8½ x 14 in)

PLEASE HELP EVALUATE THE TROLLEY'S FARE COLLECTION SYSTEM
(En Espanol En El Lado Reverso)

This questionnaire is for riders who bought a single-ride ticket at a vending machine, immediately prior to boarding the trolley. If you used a Ready Pass, a Ready 10 ticket, or a bus transfer, please request the appropriate form from the survey worker.

Nº 00372

16 **1. What is the major purpose of this trolley ride?**

- ○ Work
- ○ Social activity
- ○ School
- ○ Recreation
- ○ Shopping
- ○ Personal business (medical, banking, etc.)

17 **2. How did you learn how the fare payment system on the trolley works?**

- ○ Read the instructions at the station
- ○ Brochure or handout
- ○ Article or ad in newspaper
- ○ A trolley employee explained it
- ○ Someone else explained it

22 **3. Do you agree or disagree with the following statements about paying your trolley fare?**

	Agree	Disagree
a. The instructions at the station on how to pay are clear.	○	○
b. The ticket machines are easy to use.	○	○
c. The instructions on the ticket machines are easy to follow.	○	○
d. There should be more change machines.	○	○

4a. Most transit systems collect fares in farebox machines on the vehicle. Compared to that method, what do you feel are the advantages and disadvantages of the "self-service" fare payment method on the San Diego Trolley? (PLEASE CHECK AS MANY AS APPLY.)

30 Advantages:

- ○ Faster boarding and exiting
- ○ Fewer people cheat
- ○ More convenient
- ○ Availability of Ready 10 tickets
- ○ Don't need to deal with the driver
- ○ Other: _____

36 Disadvantages:

- ○ Harder to understand
- ○ More people cheat
- ○ The ticket machines often don't work
- ○ Time to buy or validate ticket at the station
- ○ Need to hold your ticket during the ride
- ○ Don't like being inspected
- ○ No driver present on second or third car
- ○ Other: _____

44 **4b. Which fare collection system do you prefer to use?**

○ Self-service ○ Conventional

45 **5. What, if anything, do you find confusing about the trolley's fare payment system?**

_____

46 **6. Do you know:**

	Know	Don't Know
a. How the trolley checks to see if passengers have paid their fares?	○	○
b. Whether tickets are collected?	○	○
c. The penalty for not paying the fare?	○	○
d. That you can buy monthly passes or 10-ride tickets?	○	○
e. Where to buy monthly passes or 10-ride tickets?	○	○
f. How to pay your fare when transferring between a bus and the trolley?	○	○

52 **7. Please check the answers you agree with:**

a. The $20 fine for not paying is:
○ too high ○ too low ○ just right

b. The inspectors are:
○ courteous ○ rude ○ OK

c. Being asked to show proof of payment is:
○ embarrassing ○ annoying ○ no problem

d. Passengers' tickets should be checked:
○ more often ○ less often ○ the same as now

e. The number of people who get away with riding for free is:
○ hardly any ○ a few ○ too many

57 **8. Before you began riding the San Diego Trolley, did you ever use a monthly or half-monthly transit pass?**

○ Yes ○ No

62 **9. In a typical week, how many times do you board a trolley?**

- ○ _____ times a week
- ○ Less than once a week
- ○ Only a few times a year
- ○ This is the first time I have used the trolley (IF FIRST TIME, SKIP NEXT QUESTION)

65 **10. How many months have you been using the trolley?**

_____

66 **11. Which of the following apply to you? (Check as many as apply.)**

- ○ Resident of San Diego Area
- ○ Visitor or tourist
- ○ Citizen of Mexico
- ○ Member of the Armed Forces

67 **12. At what station did you board the trolley?**

_____

69 **13. At what station will you get off the trolley?**

_____

71 **14. What is your age and sex?**

- ○ Male
- ○ Female
- ○ Under 18
- ○ 18-24
- ○ 25-44
- ○ 45-59
- ○ 60 and over

73 **15. What is the total annual income of all the people living in your home?**

- ○ Under $5,000
- ○ $5,000 - $9,999
- ○ $10,000 - $19,999
- ○ $20,000 - $29,999
- ○ $30,000 - $39,999
- ○ $40,000 or over

74 Comments:

_____

_____

_____

_____

75 *Thank you for your help! Please return your survey form to the survey worker before you leave the trolley.*

mtdb

PLEASE HELP EVALUATE THE TROLLEY'S FARE COLLECTION SYSTEM

(En Espanol En El Lado Reverso)

This questionnaire is for riders who are using a bus transfer. If you used a ticket from a vending machine, a Ready Pass, or a Ready 10 ticket, please request the appropriate form from the survey worker.

Nº 05415

1. What is the major purpose of this trolley ride?

- ○ Work
- ○ School
- ○ Shopping
- ○ Personal business (medical, banking, etc.)
- ○ Social activity
- ○ Recreation

2. How did you learn how the fare payment system on the trolley works?

- ○ Read the instructions at the station
- ○ Brochure or handout
- ○ Article or ad in newspaper
- ○ A trolley employee explained it
- ○ Someone else explained it

3. Do you agree or disagree with the following statements about paying your trolley fare?

	Agree	Disagree
a. The instructions at the station on how to pay are clear.	○	○
b. The ticket machines are easy to use.	○	○
c. The instructions on the ticket machines are easy to follow.	○	○
d. There should be more change machines.	○	○

4a. Most transit systems collect fares in farebox machines on the vehicle. Compared to that method, what do you feel are the advantages and disadvantages of the "self-service" fare payment method on the San Diego Trolley? (PLEASE CHECK AS MANY AS APPLY.)

Advantages:

- ○ Faster boarding and exiting
- ○ Fewer people cheat
- ○ More convenient
- ○ Availability of Ready 10 tickets
- ○ Don't need to deal with the driver
- ○ Other: _____

Disadvantages:

- ○ Harder to understand
- ○ More people cheat
- ○ The ticket machines often don't work
- ○ Time to buy or validate ticket at the station
- ○ Need to hold your ticket during the ride
- ○ Don't like being inspected
- ○ No driver present on second or third car
- ○ Other: _____

4b. Which fare collection system do you prefer to use?

- ○ Self-service
- ○ Conventional

5. What, if anything, do you find confusing about the trolley's fare payment system?

_____

6. Do you know:

	Know	Don't Know
a. How the trolley checks to see if passengers have paid their fares?	○	○
b. Whether tickets are collected?	○	○
c. The penalty for not paying the fare?	○	○
d. That you can buy monthly passes or 10-ride tickets?	○	○
e. Where to buy monthly passes or 10-ride tickets?	○	○

7. Please check the answers you agree with:

a. The $20 fine for not paying is:
- ○ too high
- ○ too low
- ○ just right

b. The inspectors are:
- ○ courteous
- ○ rude
- ○ OK

c. Being asked to show proof of payment is:
- ○ embarrassing
- ○ annoying
- ○ no problem

d. Passengers' tickets should be checked:
- ○ more often
- ○ less often
- ○ the same as now

e. The number of people who get away with riding for free is:
- ○ hardly any
- ○ a few
- ○ too many

8. Before you began riding the San Diego Trolley, did you ever use a monthly or half-monthly transit pass?

- ○ Yes
- ○ No

9. In a typical week, how many times do you board a trolley?

- ○ _____ times a week
- ○ Less than once a week
- ○ Only a few times a year
- ○ This is the first time I have used the trolley (IF FIRST TIME, SKIP NEXT QUESTION)

10. How many months have you been using the trolley?

_____

11. Which of the following apply to you? (Check as many as apply.)

- ○ Resident of San Diego Area
- ○ Visitor or tourist
- ○ Citizen of Mexico
- ○ Member of the Armed Forces

12. At what station did you board the trolley?

_____

13. At what station will you get off the trolley?

_____

14. What is your age and sex?

- ○ Male
- ○ Female
- ○ Under 18
- ○ 18-24
- ○ 25-44
- ○ 45-59
- ○ 60 and over

15. What is the total annual income of all the people living in your home?

- ○ Under $5,000
- ○ $5,000 - $9,999
- ○ $10,000 - $19,999
- ○ $20,000 - $29,999
- ○ $30,000 - $39,999
- ○ $40,000 or over

Comments:

_____

_____

_____

_____

Thank you for your help! Please return your survey form to the survey worker before you leave the trolley.

mtdb

PLEASE HELP EVALUATE THE TROLLEY'S FARE COLLECTION SYSTEM
(En Espanol En El Lado Reverso)

This questionnaire is for riders who used a Ready 10 ticket which they validated at a vending machine, immediately prior to boarding the trolley. If you used a Ready Pass, a single-ride ticket, or a bus transfer, please request the appropriate form from the survey worker.

Nº 04195

1. What is the major purpose of this trolley ride?

- ○ Work
- ○ School
- ○ Shopping
- ○ Personal business (medical, banking, etc.)
- ○ Social activity
- ○ Recreation

2. How did you learn how the fare payment system on the trolley works?

- ○ Read the instructions at the station
- ○ Brochure or handout
- ○ Article or ad in newspaper
- ○ A trolley employee explained it
- ○ Someone else explained it

3. Do you agree or disagree with the following statements about paying your trolley fare?

	Agree	Disagree
a. The ticket machines are easy to use.	○	○
b. The instructions on the ticket machines are easy to follow.	○	○
c. Buying a ticket for each trolley ride would be inconvenient.	○	○
d. There should be more places to buy Ready 10 tickets.	○	○

4a. Most transit systems collect fares in farebox machines on the vehicle. Compared to that method, what do you feel are the advantages and disadvantages of the "self-service" fare payment method on the San Diego Trolley? (PLEASE CHECK AS MANY AS APPLY.)

Advantages:
- ○ Faster boarding and exiting
- ○ Fewer people cheat
- ○ More convenient
- ○ Availability of Ready 10 tickets
- ○ Don't need to deal with the driver
- ○ Other: _____

Disadvantages:
- ○ Harder to understand
- ○ More people cheat
- ○ The ticket machines often don't work
- ○ Time to buy or validate ticket at the station
- ○ Need to hold your ticket during the ride
- ○ Don't like being inspected
- ○ No driver present on second or third car
- ○ Other: _____

4b. Which fare collection system do you prefer to use?

- ○ Self-service
- ○ Conventional

5. What, if anything, do you find confusing about the trolley's fare payment system?

_____

6. Do you know:

	Know	Don't Know
a. How the trolley checks to see if passengers have paid their fares?	○	○
b. Whether tickets are collected?	○	○
c. The penalty for not paying the fare?	○	○
d. How to pay your fare when transferring between a bus and the trolley?	○	○

7. Please check the answers you agree with:

a. The $20 fine for not paying is:
- ○ too high
- ○ too low
- ○ just right

b. The inspectors are:
- ○ courteous
- ○ rude
- ○ OK

c. Being asked to show proof of payment is:
- ○ embarrassing
- ○ annoying
- ○ no problem

d. Passengers' tickets should be checked:
- ○ more often
- ○ less often
- ○ the same as now

e. The number of people who get away with riding for free is:
- ○ hardly any
- ○ a few
- ○ too many

8. Before you began riding the San Diego Trolley, did you ever use a monthly or half-monthly transit pass?

- ○ Yes
- ○ No

9. In a typical week, how many times do you board a trolley?

- ○ _____ times a week
- ○ Less than once a week
- ○ Only a few times a year
- ○ This is the first time I have used the trolley (IF FIRST TIME, SKIP NEXT QUESTION)

10. How many months have you been using the trolley? _____

11. Which of the following apply to you? (Check as many as apply.)

- ○ Resident of San Diego Area
- ○ Visitor or tourist
- ○ Citizen of Mexico
- ○ Member of the Armed Forces

12. At what station did you board the trolley?

_____

13. At what station will you get off the trolley?

_____

14. What is your age and sex?

- ○ Male
- ○ Female
- ○ Under 18
- ○ 18-24
- ○ 25-44
- ○ 45-59
- ○ 60 and over

15. What is the total annual income of all the people living in your home?

- ○ Under $5,000
- ○ $5,000 - $9,999
- ○ $10,000 - $19,999
- ○ $20,000 - $29,999
- ○ $30,000 - $39,999
- ○ $40,000 or over

Comments:

_____

_____

_____

_____

Thank you for your help! Please return your survey form to the survey worker before you leave the trolley.

mtdb

6 ☐☐☐☐
10 ☐☐☐☐
14 ☐ ☐

PLEASE HELP EVALUATE THE TROLLEY'S FARE COLLECTION SYSTEM

(En Espanol En El Lado Reverso)

This questionnaire is for riders who have a monthly pass (Ready Pass). If you used a single-ride ticket, a Ready 10 ticket, or a bus transfer, please request the appropriate form from the survey worker.

Nº 06159

16 ☐ **1. What is the major purpose of this trolley ride?**

- ○ Work
- ○ School
- ○ Shopping
- ○ Personal business (medical, banking, etc.)
- ○ Social activity
- ○ Recreation

17 ☐ **2. How did you learn how the fare payment system on the trolley works?**

- ○ Read the instructions at the station
- ○ Brochure or handout
- ○ Article or ad in newspaper
- ○ A trolley employee explained it
- ○ Someone else explained it

22 ☐ **3. Do you agree or disagree with the following statements about paying your trolley fare?**

	Agree	Disagree
a. The ticket machines are easy to use.	○	○
b. Buying a ticket for each trolley ride would be inconvenient.	○	○
c. There should be more places to buy passes.	○	○
d. It is cheaper for me to buy a pass than to buy a ticket for each ride.	○	○

4a. Most transit systems collect fares in farebox machines on the vehicle. Compared to that method, what do you feel are the advantages and disadvantages of the "self-service" fare payment method on the San Diego Trolley? (PLEASE CHECK AS MANY AS APPLY.)

30 ☐☐

Advantages:

- ○ Faster boarding and exiting
- ○ Fewer people cheat
- ○ More convenient
- ○ Availability of Ready 10 tickets
- ○ Don't need to deal with the driver
- ○ Other: _____

36 ☐☐

Disadvantages:

- ○ Harder to understand
- ○ More people cheat
- ○ The ticket machines often don't work
- ○ Time to buy or validate ticket at the station
- ○ Need to hold your ticket during the ride
- ○ Don't like being inspected
- ○ No driver present on second or third car
- ○ Other: _____

44 ☐ **4b. Which fare collection system do you prefer to use?**

- ○ Self-service
- ○ Conventional

45 ☐ **5. What, if anything, do you find confusing about the trolley's fare payment system?**

_____

46 ☐☐ **6. Do you know:**

	Know	Don't Know
a. How the trolley checks to see if passengers have paid their fares?	○	○
b. Whether tickets are collected?	○	○
c. The penalty for not paying the fare?	○	○

52 ☐ **7. Please check the answers you agree with:**

a. The $20 fine for not paying is:
- ○ too high
- ○ too low
- ○ just right

b. The inspectors are:
- ○ courteous
- ○ rude
- ○ OK

c. Being asked to show proof of payment is:
- ○ embarrassing
- ○ annoying
- ○ no problem

d. Passengers' tickets should be checked:
- ○ more often
- ○ less often
- ○ the same as now

e. The number of people who get away with riding for free is:
- ○ hardly any
- ○ a few
- ○ too many

57 ☐ **8. Before you began riding the San Diego Trolley, did you ever use a monthly or half-monthly transit pass?**

- ○ Yes
- ○ No

58 ☐☐☐ **9. In a typical week, how many times do you board a trolley?**

- ○ _____ times a week
- ○ Less than once a week
- ○ Only a few times a year
- ○ This is the first time I have used the trolley (IF FIRST TIME, SKIP NEXT QUESTION)

61 ☐☐ **10. How many months have you been using the trolley?** _____

63 ☐ **11. Which of the following apply to you? (Check as many as apply.)**

- ○ Resident of San Diego Area
- ○ Visitor or tourist
- ○ Citizen of Mexico
- ○ Member of the Armed Forces

67 ☐☐ **12. At what station did you board the trolley?**

_____

69 ☐☐ **13. At what station will you get off the trolley?**

_____

71 ☐☐ **14. What is your age and sex?**

- ○ Male
- ○ Female
- ○ Under 18
- ○ 18-24
- ○ 25-44
- ○ 45-59
- ○ 60 and over

73 ☐ **15. What is the total annual income of all the people living in your home?**

- ○ Under $5,000
- ○ $5,000 - $9,999
- ○ $10,000 - $19,999
- ○ $20,000 - $29,999
- ○ $30,000 - $39,999
- ○ $40,000 or over

Comments:

74 ☐

_____

_____

_____

_____

Thank you for your help! Please return your survey form to the survey worker before you leave the trolley. 75 ☐

mtdb

POR FAVOR AYUDE A EVALUAR EL SISTEMA DE COBRO DE TARIFAS EN EL TROLLEY

Este cuestionario es para pasajeros que compraron boleto de viaje sencillo en la maquina de boletos, inmediatamente antes de abordar el trolley. Si Ud. usó un pase mensual, un boleto para 10 viajes o un boleto de transbordo de autobús, por favor solicite del trabajador de censos la forma apropiada para Ud.

1. ¿Cuál es el mayor próposito de este viaje en el trolley?
   - ○ Trabajo
   - ○ Actividad social
   - ○ Escuela
   - ○ Recreación
   - ○ De compras
   - ○ Asuntos personales (médico, banco, etc.)

2. ¿Cómo se enteró Ud. de como trabaja el sistema de tarifas del trolley?
   - ○ Leí las instrucciones en la estación
   - ○ Folleto
   - ○ Artículo o anuncio en periódico
   - ○ Un empleado del trolley me lo explicó
   - ○ Alguien más me lo explicó

3. ¿Está Ud. de acuerdo o en oposición a las siguientes declaraciones en cuanto a su pago de pasaje en el trolley?

	De Acuerdo	En Oposición
a. Las instrucciones en la estación en cuanto a como pagar están claras.	○	○
b. Las máquinas de boletos son fáciles de usar.	○	○
c. Las instrucciones en las máquinas de boletos son fáciles de seguir.	○	○
d. Debería haber más máquinas que dan cambio.	○	○

4a. La mayoría de los sistemas de tránsito cobran sus tarifas por medio de máquinas cobradoras a bordo de los vehículos. ¿ En comparación con ese método, cuáles cree Ud. que son las ventajas y desventajas del méthodo de pago "Auto Servicio" del Trolley de San Diego? (MARQUE CUANTAS CORRESPONDAN)

Ventajas
- ○ Se puede abordar o bajar más rapidamente
- ○ Menos gente hace trampa
- ○ Más conveniente
- ○ Disponibilidad de los boletos para 10 viajes
- ○ No hay necesidad de tratar con el operador
- Otras: _____

Desventajas
- ○ Más difícil de entender
- ○ Más gente hace trampa
- ○ Las máquinas de boletos seguido no funcionan
- ○ Se necesita más tiempo para comprar o revalidar boletos en la estación
- ○ La necesidad de tener a mano el boleto durante el viaje
- ○ No me gusta que me inspeccionen
- ○ Ningún operador se encuentra en el segundo o tercer carro
- ○ Otra _____

4b. ¿Cuál sistema de cobro prefiere Ud.
- ○ El "Auto Servicio"
- ○ El convencional

5. ¿Hay alguna cosa que le parezca a Ud. confusa acerca del sistema de pago de pasaje en el trolley?

_____

6. ¿Sabe Ud.:

	Sí Se	No Se
a. ¿Cómo el trolley revisa para ver si los pasajeros han pagado boleto?	○	○
b. ¿Si los boletos son recogidos?	○	○
c. ¿La multa por no pagar boleto?	○	○
d. ¿Que Ud. puede comprar pases mensuales o boletos para 10 viajes?	○	○
e. ¿Dónde comprar pases mensuales o boletos para 10 viajes?	○	○
f. ¿Cómo pagar su boleto cuando transborda de un autobus al trolley?	○	○

7. Por favor marque las respuestas con las que está de acuerdo.
   - a. La multa de $20.00 por no pagar boleto es:
     - ○ Muy alta
     - ○ Muy baja
     - ○ Adecuada
   - b. Los inspectores son:
     - ○ Amables
     - ○ Descorteses
     - ○ Más o menos
   - c. El que le pidan comprobante de pago es:
     - ○ Penoso
     - ○ Molesto
     - ○ Sin Cuidado
   - d. Los boletos de los pasajeros deberían ser revisados:
     - ○ Más seguido
     - ○ Menos seguido se
     - ○ Tan seguido como hace ahora
   - e. El número de personas que se suben sin pagar y no son aprehendidos son:
     - ○ Casi nada
     - ○ Pocos
     - ○ Demasiados

8. ¿Antes de que Ud. comenzara a viajar en el trolley de San Diego, usaba Ud. un pase mensual o medio-mensual para el uso da autobuses/camiones?
   - ○ Sí
   - ○ No

9. ¿En una semana ordinaria, cuántas veces aborda Ud. el trolley?
   - ○ _____ veces a la semana
   - ○ Menos de una vez a la semana
   - ○ Solo unas cuantas veces al año
   - ○ Esta es la primera vez que he abordado el trolley (NO CONTESTE LA SIGUIENTE PREGUNTA)

10. ¿Cuántos meses ha estado Ud. usando el trolley?

_____

11. ¿Cuál de las siguientes declaraciones le corresponde?
    - ○ Residente del Area de San Diego
    - ○ Visitante o turista
    - ○ Ciudadano de México
    - ○ Miembro de las Fuerzas Armadas

12. ¿En que estación abordó Ud. el trolley?

_____

13. ¿En que estación se bajará Ud? ?

_____

14. ¿Cuál es su edad y sexo?
    - ○ Masculino
    - ○ Femenino
    - ○ Menor de 18
    - ○ De 18 a 24
    - ○ De 25 a 44
    - ○ De 45 a 59
    - ○ 60 o más

15. ¿Cuál es el total de los ingresos anuales de todas las personas que viven en su hogar?
    - ○ Menos de $5,000
    - ○ De $5,000 a $9,999
    - ○ De $10,000 a $19,999
    - ○ De $20,000 a $29,999
    - ○ De $30,000 a $39,999
    - ○ De $40,000 o mas

Comentarios: _____

_____

_____

¡Gracias por su ayuda! Antes de bajarse del trolley, haga favor de entregar el cuestionario al trabajador de censos.

mtdb

APPENDIX C
MTDB ORDINANCE NO. 2

SAN DIEGO METROPOLITAN TRANSIT DEVELOPMENT BOARD

ORDINANCE NO. 2

An Ordinance Requiring Proof of Fare Payment
By Passengers Using the San Diego Trolley

The Board of Directors of the San Diego Metropolitan Transit Development Board (MTDB) do ordain as follows:

Section 2.1: Findings.

In 1979, by Resolution No. 79-2, MTDB adopted a self-service, barrier-free fare collection system for use with respect to the Light Rail Transit System, after finding that such a fare collection system would maximize overall productivity. Those findings are hereby reaffirmed for the San Diego Trolley System. In order to make the self-service, barrier-free fare collection system as productive and efficient as possible, it is necessary to adopt this Ordinance pursuant to Sections 120105 and 120450 of the Public Utilities Code requiring Proof of Fare Payment by passengers using the San Diego Trolley System.

Section 2.2: Definitions.

The following terms as used in this Ordinance shall have the following meaning:

A. Inspector - An officer(s) or employee(s) of MTDB, or a peace officer(s) designated by MTDB, to check passengers for valid Proof of Fare Payment with the authority to arrest and issue a Citation of Fare Evasion to passengers not possessing or exhibiting valid Proof of Fare Payment and to otherwise enforce the provisions of this Ordinance.

B. Proof of Fare Payment - Proof of Fare Payment means any of the following:

1. A monthly pass valid for use on the Trolley, purchased by or for the passenger, and valid for the time of use.

2. A single-ride ticket purchased by or for the passenger from a Trolley fare vending/validating machine. This single-ride ticket is valid provided the passenger in possession is qualified for the fare category printed on the ticket, the passenger is on a Trolley traveling in a direction away from the boarding station printed on the ticket, and the passenger is using the ticket within two hours of the date and time printed on the ticket.

3. A multi-ride ticket valid for use on the Trolley that has been validated using a Trolley fare vending/validating machine. This ticket is valid provided the passenger possessing the ticket is on a Trolley traveling in a direction away from the boarding station most recently printed on the ticket and is using the ticket within two hours of the date and time most recently printed on the ticket.

4. A valid transfer from a public bus system in San Diego County with any required upgrade-to-Trolley transfer ticket issued by an approved transit operator or from a Trolley fare vending/validating machine. All such transfers shall be valid for two hours from the date and time printed on the bus transfer ticket.

5. A copy of a Citation of Fare Evasion issued by an MTDB Inspector to the passenger within two hours of the date and time the passenger is riding on a Trolley.

C. Citation of Fare Evasion - Means the written notice to appear issued by an Inspector to a passenger arrested for violating this Ordinance whereby the passenger is released on his promise to appear in court at the date, time and place specified in the written notice.

D. Passenger - Any person occupying, riding or using any Trolley vehicle.

Section 2.3: Proof of Payment.

No unauthorized person shall occupy, ride in, or use any Trolley vehicle without possessing and exhibiting upon demand of an Inspector, valid Proof of Fare Payment.

Section 2.4: Agreement.

The use of any Trolley vehicle shall constitute an agreement by the user to pay the applicable fare in accordance with the effective fare Ordinance established by MTDB and to have in his/her immediate possession Proof of Fare Payment.

Section 2.5: Proof of Fare Payment Procedures.

A. Upon demand of an Inspector, every passenger occupying, riding or using any Trolley vehicle shall exhibit Proof of Fare Payment to the Inspector as required by this Ordinance.

B. If a passenger does not possess or exhibit valid Proof of Fare Payment, the Inspector shall arrest such passenger and if the passenger does not demand to be taken before a magistrate the Inspector shall deliver to that passenger a Citation of Fare Evasion. The Citation of Fare Evasion shall contain the name and address of the passenger, the date the citation was issued, a description of the violation, the date, time and place when and where such passenger shall appear in court, the name of the Inspector, and the signature of the passenger to whom this citation is delivered, which signature shall indicate the passenger's promise to appear in court at the date, time and place specified in the citation. The Citation of Fare Evasion shall also state a warning that the passenger's willful failure to appear in court as promised is a separate violation for which the passenger may be arrested and punished pursuant to the California Penal Code.

C. The failure or refusal of any passenger to exhibit Proof of Fare Payment, provide positive identification as to his/her full name and residence, or sign the Citation of Fare Evasion shall subject the passenger to all other provisions and remedies provided by law.

D. Failure of or refusal by the passenger to sign the Citation of Fare Evasion shall not affect the enforceability of this Ordinance.

Section 2.6: Penalties.

Any violation of Section 2.3 of this Ordinance shall be an infraction punishable by a fine not exceeding fifty dollars ($50), except that such a violation by a person, after the second conviction under this Ordinance, shall be a misdemeanor punishable by a fine not exceeding five hundred dollars ($500) or by imprisonment not exceeding six months, or by both such fine and imprisonment. For purposes of this section, a bail forfeiture shall be deemed to be a conviction of the offense charged.

Section 2.7: Public Notice.

Before the expiration of fifteen (15) days after its passage, this Ordinance shall be published once with the names of the members voting for and against the same in a newspaper of general circulation published in the County of San Diego.

PASSED, APPROVED, AND ADOPTED this 8th day of June 1981.

Chairwoman
San Diego Metropolitan
Transit Development Board

The above Ordinance was adopted by the following vote:

AYES:	Bauer, Burns, Hamilton, Hyde, Killea, O'Connor Williams
NAYES:	None
ABSENT:	Wilson
ABSTAINING:	None

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