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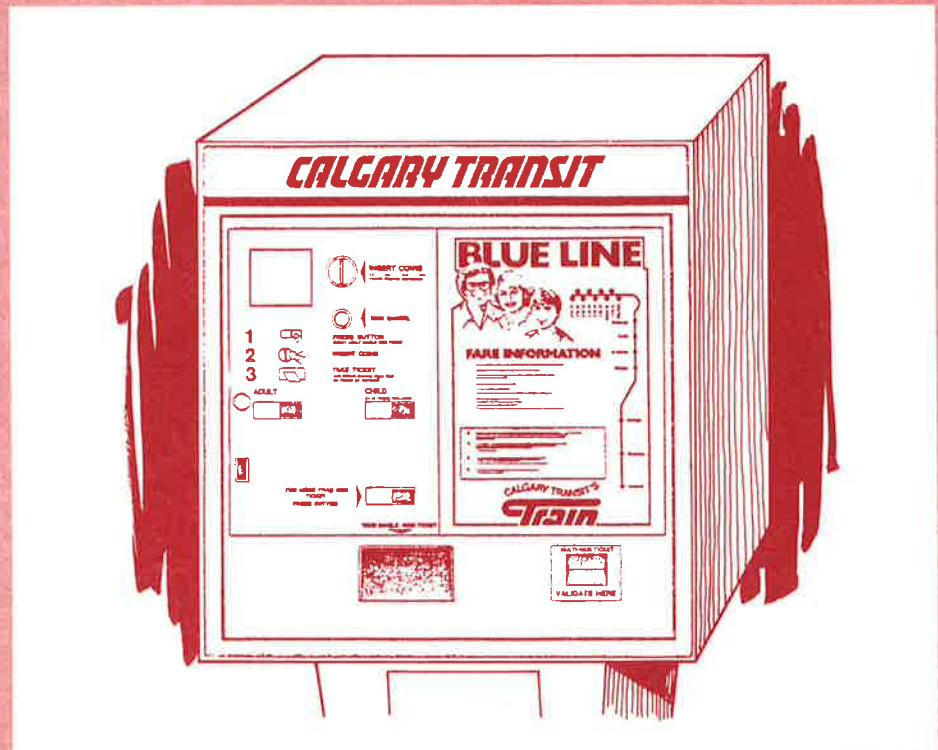
U.S. Department  
of Transportation

Urban Mass  
Transportation  
Administration

# An Assessment of Self-Service Fare Collection Equipment in Calgary and Edmonton

Mitre Corporation  
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# **An Assessment of Self-Service Fare Collection Equipment in Calgary and Edmonton**

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Under Contract to:  
Transportation Systems Center  
Office of Systems Assessment  
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Office of Technical Assistance  
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Washington DC 20590



## PREFACE

Collecting the data for this assessment would have been nearly impossible in the short time available without the cooperation and active aid of the transit systems. In both systems, individuals provided maintenance records and many hours to discuss equipment problems, to provide on-site observations of equipment repair, and to provide on-site observation of the self-service fare collection and enforcement procedures. In Calgary, Percy Cowan, Clay Switzer, Sven Madsen, Edward Koks-Porietis and Jerry Anderson generously provided their time and experience. In Edmonton, Dave Pagett, John Reid and Humberto Linarez preempted time from busy schedules to provide help.



## TABLE OF CONTENTS

<u>Section</u>		<u>Page</u>
1.	INTRODUCTION	1-1
2.	DEFINITION AND DERIVATION OF PERFORMANCE MEASURES	2-1
3.	CALGARY ASSESSMENT	3-1
	3.1 Calgary Transit System	3-1
	3.2 Calgary Data Collection	3-7
	3.3 Calgary Data Analysis and Interpretation	3-14
	3.3.1 System Performance Measured	3-14
	3.3.2 Data Interpretation	3-17
4.	EDMONTON ASSESSMENT	4-1
	4.1 Edmonton Transit System	4-1
	4.2 Edmonton Data Collection	4-7
	4.3 Edmonton Data Analysis and Interpretation	4-13
	4.3.1 System Performance Measures	4-13
	4.3.2 Data Interpretation	4-19
5.	CONCLUSION AND RECOMMENDATIONS	5-1
	5.1 Comparison With Other Equipment	5-1
	5.2 Recommendations for Subsequent Evaluations	5-3
6.	REFERENCES	6-1
	APPENDIX A - CALGARY DETAILED PERFORMANCE STATISTICS	A-1
	APPENDIX B - EDMONTON DETAILED PERFORMANCE STATISTICS	B-1

## LIST OF ILLUSTRATIONS

<u>Figure</u>		<u>Page</u>
1	CALGARY LRT ROUTE AND STATIONS	3-2
2	CALGARY TICKET MACHINE	3-4
3	SINGLE AND MULTI-RIDE TICKETS	3-6
4	EDMONTON LRT ROUTE AND STATIONS	4-2
5	EDMONTON TICKET MACHINE (WITH TURNSTILE)	4-5
6	PROOF-OF-PAYMENT TICKET	4-6
7	COMPARISON TO OTHER AFC EQUIPMENT	5-2

## LIST OF TABLES

<u>Table</u>		<u>Page</u>
ES-1	SUMMARY OF PERFORMANCE BY STATION - CALGARY	xi
ES-2	SUMMARY OF PERFORMANCE BY COMPONENT - CALGARY	xi
ES-3	SUMMARY OF JULY PERFORMANCE BY STATION - EDMONTON	xiii
ES-4	SUMMARY OF AUGUST PERFORMANCE BY STATION - EDMONTON	xiii
ES-5	SUMMARY OF SEPTEMBER PERFORMANCE BY STATION - EDMONTON	xiii
ES-6	SUMMARY OF EDMONTON COMPONENT PERFORMANCE	xiv
2-1	FORMULAS FOR PERFORMANCE MEASURES	2-2
2-2	DEFINITIONS OF INPUT DATA	2-4
3-1	DISTRIBUTION OF TICKET VENDOR/VALIDATOR MACHINES	3-3
3-2	RAW TRANSACTIONS AND FAILURE DATA	3-9



LIST OF TABLES (Continued)

<u>Table</u>		<u>Page</u>
3-3	COMPONENT FAILURES AND DOWN TIME	3-12
3-4	REORGANIZED TRANSACTION AND FAILURE DATA	3-15
3-5	SYSTEM PERFORMANCE - CALGARY	3-18
3-6	SUMMARY OF COMPONENT PERFORMANCE - CALGARY	3-19
3-7	CALGARY STATION RELIABILITY AND AVAILABILITY	3-20
3-8	RELIABILITY 95 PERCENT CONFIDENCE INTERVAL - CALGARY	3-22
3-9	VALIDATION EFFECT ON SYSTEM PERFORMANCE	3-25
4-1	DISTRIBUTION OF EDMONTON TICKET MACHINES	4-3
4-2	COMPONENT FAILURE AND DOWN TIME	4-8
4-3	JULY TRANSACTIONS AND FAILURES	4-9
4-4	AUGUST TRANSACTIONS AND FAILURES	4-10
4-5	SEPTEMBER TRANSACTIONS AND FAILURES	4-11
4-6	JULY TO SEPTEMBER TRANSACTIONS AND FAILURES	4-12
4-7	JULY PERFORMANCE - EDMONTON	4-14
4-8	AUGUST PERFORMANCE - EDMONTON	4-15
4-9	SEPTEMBER PERFORMANCE - EDMONTON	4-16
4-10	JULY TO SEPTEMBER PERFORMANCE - EDMONTON	4-17
4-11	SUMMARY OF COMPONENT PERFORMANCE - EDMONTON	4-18
4-12	EDMONTON STATION RELIABILITY AND AVAILABILITY	4-20
4-13	SEPTEMBER RELIABILITY 95 PERCENT CONFIDENCE INTERVALS - EDMONTON	4-22
4-14	JULY TO SEPTEMBER RELIABILITY 95 PERCENT CONFIDENCE INTERVALS - EDMONTON	4-22



## EXECUTIVE SUMMARY

An assessment of Self-Service Fare Collection (SSFC) equipment was conducted for two light rail transit (LRT) systems in the Canadian cities of Calgary and Edmonton in Alberta province. The assessment was sponsored by the U.S. Department of Transportation, Urban Mass Transportation Administration, Office of Technical Assistance, and was monitored by the Transportation Systems Center, U.S. Department of Transportation, Cambridge, MA. It was conducted according to the Property Evaluation Plan (PEP) developed by Input Output Computer Services, Inc. for TSC (Ref. 1), in cooperation with the rail transit systems in the U.S. Additional measures of station and system availability were computed because they were considered necessary to assess performance with the self-service operations. The purpose of the assessment was to create a basis of comparison for new and planned SSFC systems in the United States by using the experience of these well established and successful systems in these two Canadian cities.

### Calgary Transit

Calgary's SSFC equipment consists of 43 ticket vending/validating machines manufactured for Calgary by XAMAX AG of Zurich, Switzerland. Forty-one of these machines are installed at 12 of the 16 LRT stations. Twenty-two machines are located inside six heated stations. The other 19 are exposed or partially exposed to the severe weather experienced by this northern city.

The machines dispense single-ride, time-limited, adult or children's tickets and will validate multi-ride tickets purchased elsewhere. The machine does not make change, but will return the coins deposited if the reject button is pressed. The machine is capable of detecting some failures, and transmits an alarm to a central monitoring station where maintenance personnel can be dispatched.

### Calgary Data Collection

Data for the assessment were obtained by reviewing system-maintained data records, and by discussions with maintenance personnel during a visit to Calgary from November 15 to 17, 1982. Complete records for transactions and failures were available for a survey period starting on April 8, 1982 and ending on July 26, 1982 which covered 109 days or 2180 hours of operations. Down time data defined in the PEP procedures were not recorded by Calgary, so estimates for the various types of failures were made after discussions with the maintenance personnel. The survey period included the week long Calgary Stampede in July which increased LRT ridership more than

ten-fold. The machines collectively recorded 1,266,260 transactions (ticket dispensed or validated) with 502 failures of various types during this period. The mean transactions per failure (MTF) was 2,522.

#### Calgary Ticket Machine Performance

Tables ES-1 and ES-2 summarize the performance of the machines by station and by component, respectively. Each table shows the input data (transactions, operational time, failures down time) on the left, and the computed performance measures (Reliability (R), Availability (A), Average Down Time (ADT), and Mean Time to Repair (MTTR)) on the right.

There was a seven to one variation in the number of transactions recorded across the stations with a four to one variation for failures and MTF. For the most part, stations with a higher number of transactions also had a higher MTF. Hard failures (those requiring repair or replacement of parts) ranged from none at Southland to 23 at Center Street. Each station exhibited average availabilities in excess of 99.5 percent. The average down time (ADT) at each station was approximately three quarters of an hour, and the mean time to repair (MTTR) was close to an hour. Both of these measures contained a fixed time estimate of 30 minutes for response time.

The ticket dispenser accounted for the greatest proportion of failures (49 percent), largely due to ticket stock running out and printer ribbons wearing out. It accounted for 78 percent of the hard failures, largely due to tickets stuck in the guillotine. The cash box accounted for 20 percent of the failures, largely due to the cash box becoming full before the regular cash pick-up was made. A design weakness in the cash box has forced Calgary to use an outside armored car service with bonded and armed guards making the cash pickups. Calgary is now taking steps to strengthen or replace this box, so they can make more frequent pickups with their own personnel in the future. Also, they are modifying the failure detection system in the machine to send an error code to the central monitoring station when the cash box is nearly full.

#### Edmonton Transit

Edmonton's SSFC equipment consists of 40 ticket vending machines manufactured by Duncan Industries, Inc. of Chicago. All machines are installed on the inside of the six heated LRT stations. Thirty-four of the machines still have turnstiles which remain from the original barrier and fare agent collection system. The turnstile tripod is now free-wheeling, and is no longer a source of failures. Six of the machines, one per station, do not have turnstiles, and are located away from the general passenger flow. They were installed when the system was converted to SSFC to aid handicapped passengers in wheelchairs.

**TABLE ES-1**  
**SUMMARY OF PERFORMANCE BY STATION - CALGARY**

LOCATION	TRANS	OP TIME (HRS)	TOTAL FAILS	TOTAL DOWN TIME (HRS)	TOTAL HARD FAILS	TOTAL DOWN TIME HARD (HRS)	R	MTF	MTBF (HRS)	A	ADT (HRS)	MTTR (HRS)
ANDERSON	135722	8720	66	47.17	6	6.33	.999645	2814	132.12	.994591	0.71	1.06
SOUTHLAND	97045	6540	28	20.71	0	0.00	.999711	3466	233.57	.996834	0.74	NA
HERITAGE	99962	6540	31	22.06	3	2.25	.999690	3225	210.97	.996627	0.71	0.75
CHINOOK	139553	6540	48	33.67	12	10.33	.999656	2907	136.25	.994852	0.70	0.36
42ND AVE	49072	4360	43	32.75	17	16.17	.999124	1141	101.40	.992489	0.76	0.95
ERLTON	43800	6540	18	11.67	5	4.25	.999589	2433	363.33	.998216	0.65	0.85
STAMPED	138676	8720	41	28.00	2	1.92	.999704	3382	212.68	.996789	0.68	0.96
CITY HALL	59038	8720	39	29.81	11	10.67	.999339	1514	223.59	.996581	0.76	0.97
CENTRE ST	161565	8720	72	54.46	23	20.42	.999554	2244	121.11	.993755	0.76	0.89
3RD ST W	144835	8720	46	34.04	8	7.42	.999682	3149	189.57	.996096	0.74	0.93
6TH ST W	75290	8720	39	28.56	11	8.75	.999482	1931	223.59	.996724	0.73	0.80
8TH ST W	71702	6540	31	23.83	12	12.17	.999568	2313	210.97	.996356	0.77	1.01
SYSTEM	1266260	89380	502	366.73	110	100.67	.999604	2522	178.05	.995897	0.73	0.92

**TABLE ES-2**  
**SUMMARY OF PERFORMANCE BY COMPONENT - CALGARY**

COMPONENT	TRANS	OP TIME (HRS)	TOTAL FAILS	TOTAL DOWN TIME (HRS)	TOTAL HARD FAILS	TOTAL DOWN TIME HARD (HRS)	R	MTF	MTBF (HRS)	A	ADT (HRS)	MTTR (HRS)
ELECTRONIC CH.	1266260	89380	12	17.81	3	3.75	.999991	105521	7448	.999801	1.48	1.25
COIN ACCEPTOR	1266260	89380	78	47.33	7	6.75	.999938	16234	1146	.999470	0.61	0.96
TICKET DISPENSER	1266260	89380	247	184.67	86	77.33	.999805	5127	362	.997934	0.75	0.90
TICKET VALIDATOR	1266260	89380	49	36.08	0	0.00	.999961	25842	1824	.999596	0.74	NA
FRONT DOOR ASSB.	1266260	89380	9	9.08	9	9.08	.999993	140694	9931	.999898	1.01	1.01
BATT. & CHARGER	1266260	89380	5	3.75	5	3.75	.999996	253248	17876	.999958	0.75	0.75
CASH BOX	1266260	89380	102	68.00	0	0.00	.999919	12414	876	.999239	0.67	NA
SYSTEM	1266260	89380	502	366.72	110	100.66	.999604	2522	178	.995897	0.73	0.92

The machines dispense single-ride, time-limited, adult or children's tickets. The machine does not make change nor can it return coins deposited. It dispenses a ticket when the correct or greater amount of coins have been deposited. Any overpayment is "remembered" by the machine for 40 seconds, and may be used by the next passenger within the 40 second period.

#### Edmonton Data Collection

Input data for the assessment were obtained by reviewing system-maintained data records, and by discussions with maintenance personnel during a visit to Edmonton from November 18 to 19 in 1982. Records for transactions and failures were reviewed for the months of July, August and September 1982, which covered 620, 620, and 600 hours of operation, respectively. Down time data defined in the PEP procedures were not recorded by Edmonton, so estimates for the various types of failures were made after discussions with maintenance personnel. The month of July includes Edmonton's Klondike Days which increases LRT ridership more than sixteen-fold over the months of August or September. The number of transactions (tickets dispensed) during these months was 2,447,913, 164,823 and 144,226 respectively, with 391, 247 and 287 failures. The MTFs for these three months were 6,261, 667 and 503.

#### Edmonton Ticket Machine Performance

Tables ES-3, ES-4 and ES-5 summarize the performance of the machines by station for the three survey months. Table ES-6 summarizes the performance of the machines by component for the combined three month period.

The most important observation when comparing the three months is that the number of failures does not increase proportionately with the number of transactions. The July transactions are roughly 16 times greater than either August or September while the July failures are only about 1.5 times greater. This disparity may also be seen in the ten to one difference in MTF for July versus the other months. While there is no hard evidence, it is possible that the greater passenger flow may discourage vandalism of the machines, particularly the practice of stuffing pieces of paper in the coin mechanism. Further, certain mechanical failures such as ticket or coin jams may be related to periods of non-use such as overnight or between the morning and evening rush hours when the loop of ticket stock closest to the dispenser has a chance to gain (or lose) moisture content faster than the rest of the fan-fold stock, or the coin chutes becomes sticky from congealing body oils brought in by the coins. This large difference in reliability with the volume of transactions should be studied more carefully.

TABLE ES-3  
SUMMARY OF JULY PERFORMANCE BY STATION - EDMONTON

LOCATION	TRANS	FAILS	OP TIME (HRS)	DOWN TIME (HRS)	HARD FAIL	HARD DOWN TIME (HRS)	R	MTF	MTBF (HRS)	A	ADT (HRS)	MTTR (HRS)
CENTRAL	679741	120	5580	80.67	14	10.00	.99982	5665	46.50	.98554	0.67	0.71
CHURCHILL	401677	48	4340	34.00	10	8.67	.99988	8368	90.42	.99217	0.71	0.87
STADIUM	288520	42	4340	29.17	10	7.83	.99985	6870	103.33	.99328	0.67	0.78
COLISEUM	485757	75	5580	50.67	15	10.67	.99985	6477	74.40	.99092	0.68	0.71
BELVEDERE	364056	47	1860	32.67	5	4.67	.99987	7746	39.57	.98244	0.70	0.93
CLAREVIEW	228162	59	3100	39.33	7	5.17	.99974	3867	52.54	.98715	0.68	0.74
SYSTEM	2447913	391	24800	267.00	61	47.00	.99984	6261	63.43	.98923	0.68	0.77

TABLE ES-4  
SUMMARY OF AUGUST PERFORMANCE BY STATION - EDMONTON

LOCATION	TRANS	FAILS	OP TIME (HRS)	DOWN TIME (HRS)	HARD FAIL	HARD DOWN TIME (HRS)	R	MTF	MTBF (HRS)	A	ADT (HRS)	MTTR (HRS)
CENTRAL	51444	71	5580	49.17	17	13.17	.99862	725	78.59	.99119	0.69	0.77
CHURCHILL	27415	23	4340	15.67	3	2.33	.99916	1192	188.70	.99639	0.68	0.78
STADIUM	24293	31	4340	21.50	7	5.50	.99872	734	140.00	.99505	0.69	0.79
COLISEUM	17058	46	5580	34.33	10	15.67	.99730	371	121.30	.99385	0.75	0.87
BELVEDERE	27846	38	1860	26.33	8	6.33	.99864	733	48.95	.98584	0.69	0.79
CLAREVIEW	16765	38	3100	28.17	14	12.17	.99773	441	81.58	.99091	0.74	0.97
SYSTEM	164823	247	24800	175.17	67	55.17	.99850	667	100.40	.99294	0.71	0.82

TABLE ES-5  
SUMMARY OF SEPTEMBER PERFORMANCE BY STATION - EDMONTON

LOCATION	TRANS	FAILS	OP TIME (HRS)	DOWN TIME (HRS)	HARD FAIL	HARD DOWN TIME (HRS)	R	MTF	MTBF (HRS)	A	ADT (HRS)	MTTR (HRS)
CENTRAL	43446	87	5400	60.67	22	17.33	.99800	499	62.07	.98877	0.70	0.79
CHURCHILL	23903	32	4200	22.17	5	4.17	.99866	747	131.25	.99472	0.69	0.83
STADIUM	18767	49	4200	34.50	16	12.50	.99739	383	85.71	.99179	0.70	0.78
COLISEUM	20436	44	5400	31.17	10	8.50	.99785	464	122.73	.99423	0.71	0.85
BELVEDERE	23900	30	1800	20.67	5	4.00	.99874	797	60.00	.98852	0.69	0.80
CLAREVIEW	13774	45	3000	30.33	5	3.67	.99673	306	66.67	.98989	0.67	0.73
SYSTEM	144226	287	24000	199.50	63	50.17	.99801	503	83.62	.99169	0.70	0.80

TABLE ES-6  
SUMMARY OF EDMONTON COMPONENT PERFORMANCE

COMPONENT	TRANS	OP TIME (HRS)	TOTAL FAILS	TOTAL DOWN TIME (HRS)	TOTAL HARD FAILS	TOTAL DOWN TIME HARD (HRS)	TOTAL			ADT (HRS)	MTTR (HRS)	
							R	MTF	MTBF			
ELECTRONIC CH.	2974022	73600	19	16.00	10	10.00	.999994	156526	3073.66	.999783	0.84	1.00
COIN MECH.	2974022	73600	287	197.33	65	49.33	.999903	10362	256.45	.997319	0.69	0.76
TICKET DISP.	2974022	73600	513	345.33	10	10.00	.999826	5797	143.47	.995308	0.67	1.00
CASH STORAGE	2974022	73600	15	10	15	10	.999995	198267	4906.67	.999864	0.67	0.67
ELECTRIC SYS.	2974022	73600	61	43.00	61	43.00	.999979	48754	1206.56	.999416	0.70	0.70
MISC.	2974022	73600	30	30.00	30	30.00	.999990	99134	2453.33	.999592	1.00	1.00
SYSTEM	2974022	73600	925	641.66	191	152.33	.999689	3215	79.57	.991282	0.69	0.80



All stations demonstrated an average availability in excess of 99.1 percent. The average down time (ADT) at each station was approximately three quarters of an hour, and the mean time to repair was somewhat greater.

The distribution of failures across components over the July to September period (see Table ES-6) shows that the ticket dispenser had the largest number of failures (55 percent) followed by the coin mechanism (31 percent). The coin mechanism had the greatest number of hard failures (34 percent) where repair or replacement of parts was required. The electrical system had the second largest (32 percent), mainly because of lamps burning out.

#### Comparison to Similar Equipment

In an earlier study by Deibel and Wood (Ref. 2), a comparison of automatic fare collection equipment ranging from simple token equipment to sophisticated magnetic card systems was made. Their approach was to group the various equipment by the number of functions performed rather than by the sophistication of the electronics, mechanics, or media. They found that, generally, machines with the same number of functions also had similar reliabilities. Applying the same criteria, the ticket machines used by both Calgary and Edmonton have reliabilities and MTFs similar to equipment with an equivalent number of functions.



## 1. INTRODUCTION

An assessment of Self-Service Fare Collection (SSFC) equipment was conducted for two light rail (LRT) systems in the Canadian cities of Calgary and Edmonton in Alberta province for the U.S. Department of Transportation, Urban Mass Transportation Administration, Office of Technical Assistance. The work was done under contract to the Transportation Systems Center, U.S. Department of Transportation, Cambridge, MA. The data collection, data analysis and presentation of results were done according to the uniform procedures defined in TSC's Property Evaluation Plan (PEP) (Ref. 1), which has been used to evaluate several United States and European transit systems (Refs. 3, 4, 5). The SSFC concept has been successfully applied in Europe and Canada, and is starting to be applied in the United States. There is a need for transit systems considering the SSFC approach to evaluate the experience and performance of existing systems in cities that are comparable to U.S. cities, and to then later use the same procedures to evaluate the performance of their own SSFC equipment.

Data for the assessment were collected from system maintained data, and from conversations with maintenance personnel during visits to Calgary (November 15-17, 1982) and Edmonton (November 18-19, 1982). At both transit systems, the survey periods chosen were based somewhat on completeness of the records, and upon the ease with which data could be extracted in the short time available during the visits. The periods chosen--April to July 1982 for Calgary, and July to August 1982 for Edmonton--fortunately contained periods of both normal and extremely high ridership. The internationally known Calgary Stampede and Edmonton's Klondike Days, both held during July, caused a more than ten-fold increase in ridership.

The PEP procedures are presented and discussed briefly in Section 2. The Calgary and Edmonton systems and equipment are described and analyzed in Sections 3 and 4, respectively. The Calgary and Edmonton SSFC equipment is compared to automatic fare collection equipment of similar complexity at other transit systems in Section 5. The appendices contain additional detailed performance measures for each machine individually at the component level.



## 2. DEFINITION AND DERIVATION OF PERFORMANCE MEASURES

Three categories of performance measures--reliability, availability, and maintainability--were defined for transit systems in the report "Automatic Fare Collection Property Evaluation Plan" (Ref.1). For convenience, these definitions will be repeated and discussed briefly in this section. The input data required to compute these measures are also defined, and discussed, where necessary, relative to the Calgary and Edmonton assessments.

Reliability is defined as the probability that a system and its subsystems will successfully accomplish their functional tasks. Three measures of reliability are used in this report:

- R -- Reliability (probability of a successful transaction)
- MTF -- Mean Transactions Per Failure
- MTBF -- Mean Time Between Failures

The formulas for these three measures are given in Table 2-1. Mean time between failures (MTBF), as defined by the PEP and computed at the station or the system level, is an average MTBF for a particular station or the overall system. This average MTBF is useful for general comparisons between stations and for comparisons between the system being evaluated and other transit systems. Table 2-1 also defines a second MTBF statistic (MTBF2) that provides a measure of the frequency with which maintenance actions are required at individual stations and within the entire system. This latter MTBF indicates the relative maintenance demands posed by each station.

Availability is the probability that a system and its subsystems will be operating satisfactorily at any point in time. Three measures of availability are calculated at the station and the system level in this assessment and are defined in Table 2-1. The first is availability as defined by the PEP. As in the computation of MTBF, it is an average availability both at the station level and at the system level. The second availability measure indicates the probability that all machines at a given station are functioning, and is also a performance measure indicating the probability that passengers will not experience a delay due to a machine failure. The third availability measure indicates the probability that at least one machine at any given station is operational. This probability is particularly critical in a self-service system since it indicates the probability that a passenger can obtain the required proof-of-payment.

TABLE 2-1  
FORMULAS FOR PERFORMANCE MEASURES

Reliability:

$$R = \frac{\text{Total Transactions} - \text{Total Failures}}{\text{Total Transactions}}$$

$$MTF = \frac{1}{(1-R)}$$

$$MTBF = \frac{\text{Total Operating Time}}{\text{Total Failures}}$$

Station Level MTBF:

$$\text{MTBF1 (PEP Definition)} = \frac{\text{Sum of Operating Time of Station Machines}}{\text{Sum of Failures--All Machines}}$$

$$\text{MTBF2} = \frac{\text{Average Operating Time--All Machines}}{\text{Sum of Failures--All Machines}}$$

Availability:

$$A = \frac{\text{Total Operating Time} - \text{Total Down Time}}{\text{Total Operating Time}}$$

Station Level Availability:

$$\text{A1 (PEP Definition)} = \frac{\text{Summation of Operating Time} - \text{Total Down Time}}{\text{Summation of Operating Time}}$$

$$\text{A2 (All Machines Operational)} = \frac{\text{Average Machine Operating Time} - \text{Total Down Time}}{\text{Average Machine Operating Time}}$$

$$\text{Minimum Availability (At least one Machine Operational)} = 1 - \prod_i (1 - A_{\text{machine } i})$$

Maintainability:

$$\text{ADT} = \frac{\text{Total Down Time}}{\text{Total Failures}}$$

$$\text{MTTR} = \frac{\text{Total Down Time (Hard Failures Only)}}{\text{Total Hard Failures}}$$

Maintainability is defined as the time required to repair failures. Two measures of maintainability are used in this report:

ADT -- Average Down Time  
MTTR -- Mean Time to Repair

The formulas for these measures are also given in Table 2-1. ADT indicates the average time the equipment will be out of service per failure for all failures (soft and hard). MTTR indicates the average only for hard failures. The distinction between ADT and MTTR hinges upon the distinction between soft and hard failures and their associated down times which are defined later.

Each of the six performance measure formulas in Table 2-1 depends upon one or more of the following sets of input data:

Total Transactions  
Total Failures  
Total Operational Time  
Total Down Time  
Total Hard Failures  
Total Down Time (Hard failures Only)

The definitions for each of these six sets are presented in Table 2-2.

One final statistic computed for each transit system is the confidence interval for the reliability measure R. This statistic provides a measure of the possible error contained in the computed R relative to the true reliability. The confidence interval also provides a measure of assurance that reliability of a machine will, with 95 percent probability, fall within an interval that is a function of the computed reliability, R, for a given sample of data. This interval, known as a 95 percent Confidence Interval is defined as:

$$R - 1.96 \sqrt{\frac{R(1-R)}{N}} \quad \text{to} \quad R + 1.96 \sqrt{\frac{R(1-R)}{N}}$$

R is the computed reliability defined earlier and N is the number of transactions. A greater number of transactions will yield a much tighter interval. That means that R is a much better estimate of the true reliability.

TABLE 2-2  
DEFINITIONS OF INPUT DATA

Total Transactions

Defined separately for each system or subsystem. Some examples are tickets dispensed, passengers counted or coins accepted.

Total Failures

Defined separately for each system or subsystem. Some examples are the number of coin jams, number of fuses blown, number of times machine could not dispense tickets.

Total Operational Time

Defined as the time when the system or subsystem should be in use or available for use. For example, if a transit system operates 20 hours per day then the operational time for the system is 20 hours multiplied by the days in the survey period.

Total Down Time

Defined as the interval between the failure of equipment and the return of that equipment to service. In this report down time consists of response time plus on-site diagnosis and/or repair time. During the survey periods for both transit systems, sufficient spare parts were available to make on-site replacement and off-site repair feasible. Thus off-site repair time was not included in down time.

Total Hard Failure

Defined as failures that require repair work by a maintenance technician as opposed to soft failures such as simple coin or ticket jams that could be or are cleared by fare inspectors or those who collect the cash boxes. (In Calgary and Edmonton all failures are corrected by maintenance technicians.)

Total Down Time (Hard Failures only)

Defined as the interval between the hard failure of equipment and the return of that equipment to service. (See Total Down Time for comments on response time, on-site time and off-site time.)



All of the data aggregation, computation, and most of the generation of tables in this report was done with the help of the VisiCalc(TM) software package running on an Apple II(TM) Microcomputer. The software allows the user to create the equivalent of an accountant's spread sheet, and to see and manipulate data within the sheet via a keyboard and CRT monitor in real time. Rows and columns of data can be moved within a sheet or from sheet to sheet.

In this report, spread sheets were first created that closely matched the format of the data charts received from the transit systems or from notes extracted from maintenance records. Data were then entered directly to the equivalent spread sheet cells, and later a printout of the spread sheet was compared to the original data.

The ability to quickly enter and verify data in familiar formats, to then reorganize that data into formats more closely associated to the desired performance measures, and to then perform trial computations before final printouts greatly aided the data analysis presented in Sections 3.3 and 4.3. The VisiCalc(TM) package provided customized data manipulation and analysis without having to write a customized computer program.



### 3. CALGARY ASSESSMENT

#### 3.1 Calgary Transit System

The city of Calgary in the Alberta province of Canada provides mass transit service to its population of over 500,000 people through its Transportation Department. The fleet of over 600 buses uses conventional fareboxes. The Light Rail Transit (LRT) system which has been in operation since May 25, 1981 was designed for and exclusively uses a Self-Service Fare Collection (SSFC) system. The SSFC equipment consists of forty-three XAMAX BA2000 Ticket Vending/Validating machines manufactured for Calgary by XAMAX AG of Zurich, Switzerland. Major repairs and warranty work are done by the Canadian firm, Automatec of Montreal. Automatec has also been responsible for significant on-site work including a major adjustment of the equipment in April of 1982. This adjustment was completed just prior to the beginning of the equipment survey period used in this report.

Calgary's LRT system consists of sixteen LRT stations along a 12.5 kilometer (7.8 miles) right-of-way that starts in the southern suburbs and terminates at the end of a free fare zone transit mall. The map in Figure 1 shows the location of the stations as heavy bold blocks. The southern leg of the LRT is an exclusive right-of-way partially underground with some gate-protected grade-level crossings. East-west along 7th Avenue, which is restricted to transit vehicles (buses, LRT and maintenance), the LRT runs at grade level, and drivers must obey traffic signals controlling the flow of general cross traffic.

Stations in the free fare zone along 7th Avenue are located on separate sides of the street. The stations on the inbound north side of the street do not have ticket machines. The stations on the outbound south side do have machines. A total of forty-one machines are distributed among the twelve stations as indicated in Table 3-1.

Twenty ticket machines are located within enclosed heated stations. The other twenty-one machines are located on open platforms either fully exposed to the weather or partially sheltered by a narrow roof approximately 3.5 meters (11.5 feet) above platform level.

The ticket machines (see Figure 2) dispense single-ride, time-limited, adult or children's tickets, and validate multi-ride tickets purchased elsewhere. All LRT passengers are

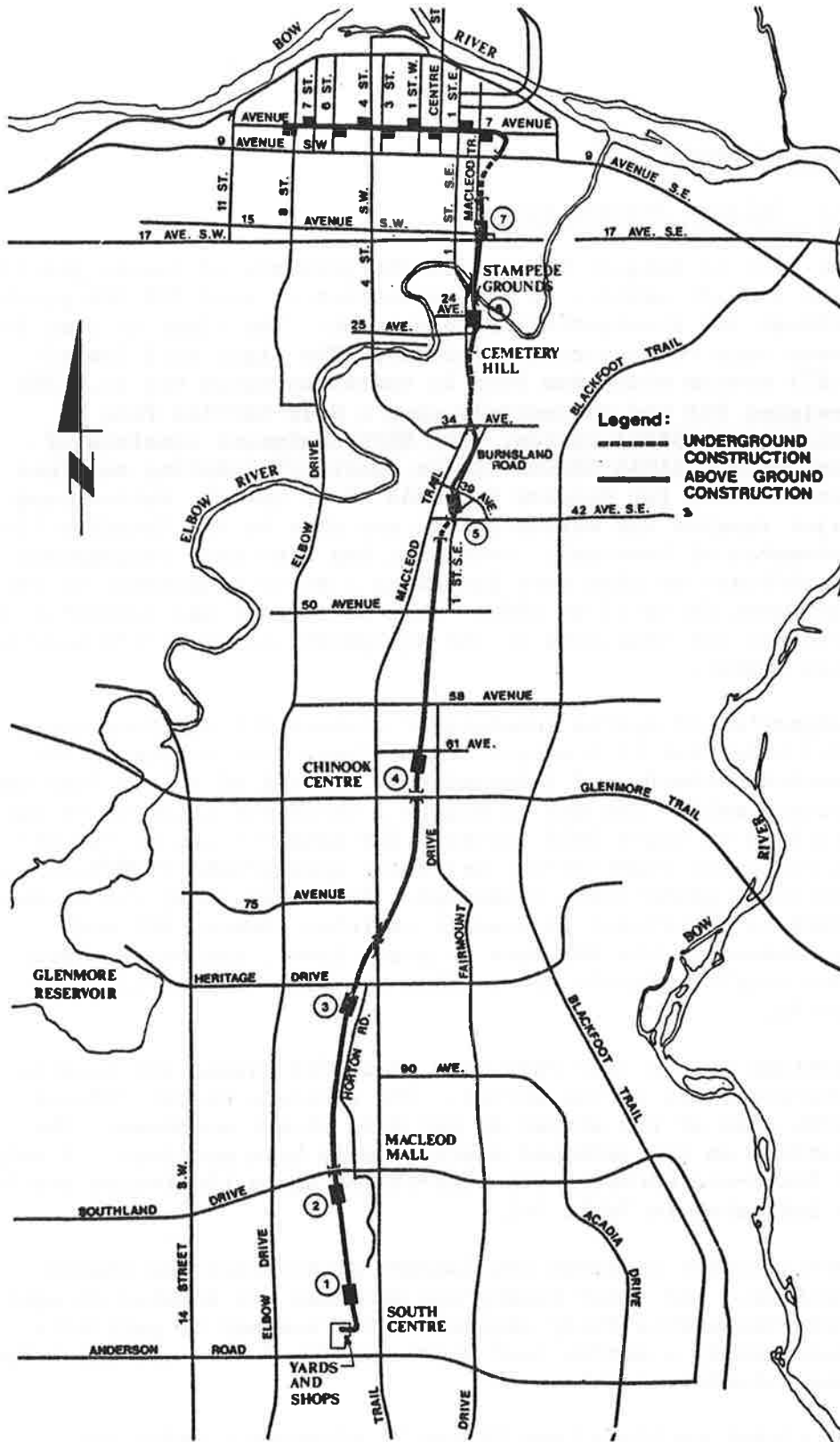


FIGURE 1  
CALGARY LRT ROUTE AND STATIONS

TABLE 3-1  
DISTRIBUTION OF TICKET VENDOR/VALIDATOR MACHINES

Station	Direction	Machine Numbers*	Machine** Location	
South Leg Stations	ANDERSON	either	1, 2, 3, 4	closed
	SOUTHLAND	either	5, 7, 6	closed
	HERITAGE	either	8, 9, 10	closed
	CHINOOK	either	11, 12, 34	closed
	42nd AVE	either	14, 13,	open
	ERLTON	either	15, 16, 17	closed
	STAMPEDE	either	21, 18, 19, 20	closed
7th Ave Free Fare Zone	CITY HALL	outbound	22, 23, 24, 25	open
	1st ST E	inbound	none	
	CENTER ST	outbound	29, 28, 27, 26	open
	1st ST W	inbound	none	
	3rd ST W	outbound	30, 31, 32, 33	open
	4th ST W	inbound	none	
	6th ST W	outbound	35, 36, 37, 38	open
	7th ST W	inbound	none	
8th ST W	either	39, 40, 41	open	
Spares		42, 43		

\*Machine numbers are referenced in the order of location within each station or platform.

\*\*Closed vs. open--to the weather

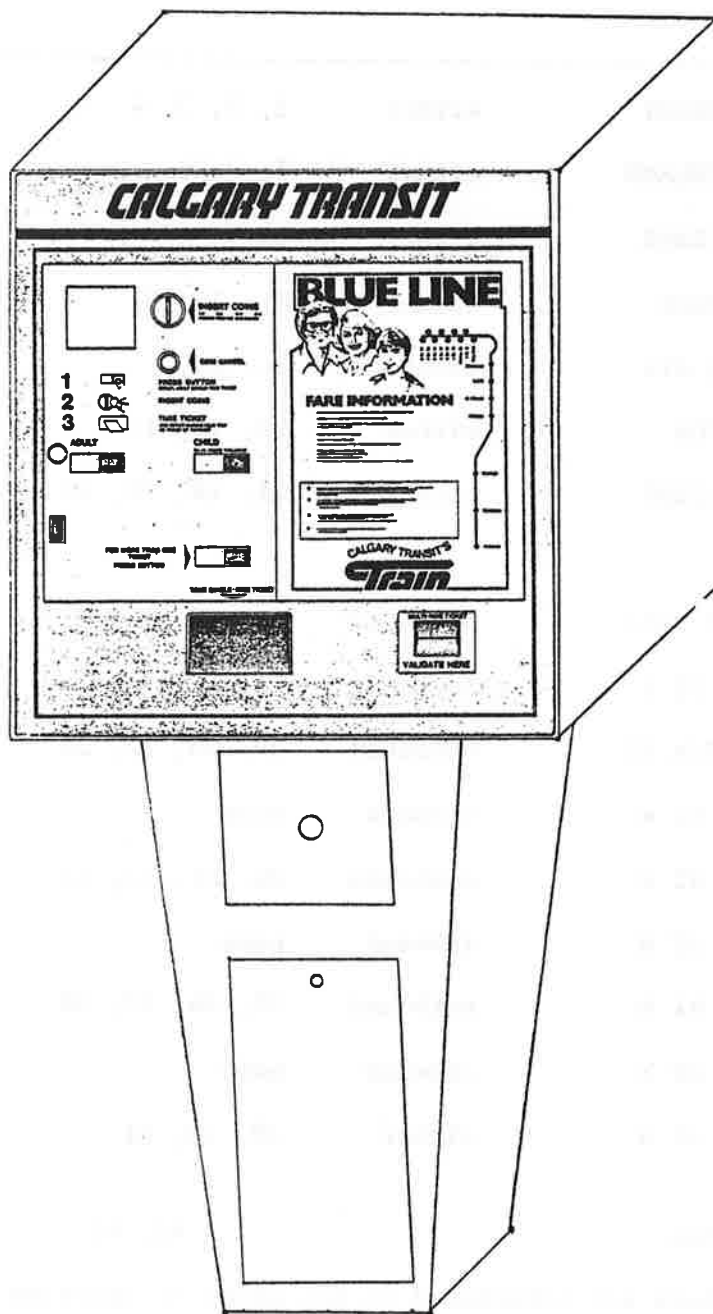


FIGURE 2  
CALGARY TICKET MACHINE

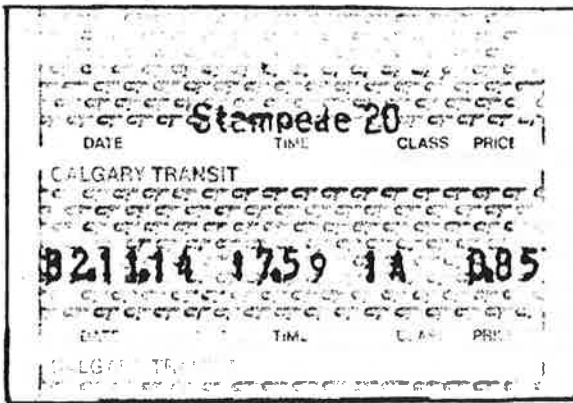
required by law to have on their person proof that they have paid for a ride on the LRT whenever they are in a 'proof-of-payment' area. The "proof-of-payment" areas are located both at the platforms of those stations outside of the 7th Avenue free fare zone (see Table 3-1), and inside the LRT vehicle when the vehicle is outside of the free fare zone. Valid proofs-of-payment may be the tickets dispensed or validated by the ticket machines, bus transfers or a variety of transit passes.

The ticket machine consists of eight major components:

- Electronic Chassis Subassembly
- Coin Acceptor Subassembly
- Ticket Dispenser Subassembly
- Ticket Validator Subassembly
- Front Door Subassembly
- Battery and Charger Subassembly
- Cash Box
- Alarm and Communications Subassembly

The electronic chassis subassembly consists of eight printed circuit boards (PCB) that contain a microprocessor, date/clock, and interfacing circuitry that control the operation of the other subassemblies. The coin acceptor subassembly accepts, tests and counts Canadian five-cent, ten-cent, and twenty-five cent coins. Coins are held in escrow until the correct amount has been deposited. The ticket dispenser subassembly prints, cuts and dispenses single-ride tickets from a continuous roll of bank-check quality paper with a preprinted forgery resistant background (see Figure 3). The ticket validator successively chops a numbered chip (1-10) out of the upper left hand corner of a multi-ride ticket (see Figure 3), and prints the station identification and time on the next available line. Each multi-ride ticket is valid for ten rides. The front door subassembly contains a four digit cash-entered display, adult and child fare buttons, coin cancel button, coin insert slot, multi-ride ticket validating slot, and a dish where rejected coins are returned and single ride tickets are dispensed. The battery and charger subassembly provides power backup, and surge current to operate the validator. The battery contains enough charge to maintain the digital clock for 48 hours or to operate the machine for two hours. The alarm and communications subsystem transmits an alarm signal when the machine is malfunctioning, or when any compartment has been opened. The compartment-open alarm is not functional now, but will be in early 1983.

Single Ride  
Ticket



Station: Stampede  
 Machine: # 20  
 Date: November 14, 1982  
 Time: 5:59 P.M.  
 Class: Single Adult  
 Price: 85 cents

Multi-Ride  
Ticket

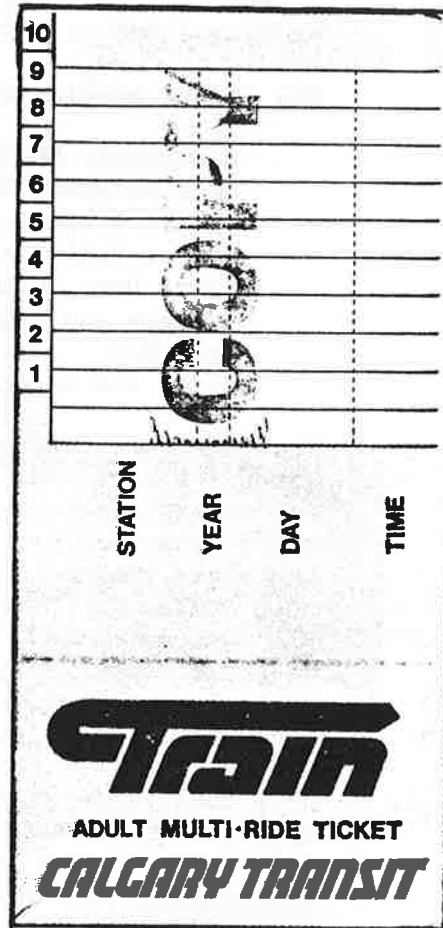


FIGURE 3  
SINGLE AND MULTI-RIDE TICKETS



### 3.2 Calgary Data Collection

Calgary maintenance personnel record failure data for each machine chronologically as failures occur. These initial records are handwritten on-site with a brief description of each failure and its date of occurrence. Later, these handwritten records are reviewed, the failures are categorized, and a chart showing the number of failures per machine per failure category over a particular survey period is produced. A reproduction of this chart for the April 8, 1982 to July 26, 1982 survey period is shown in Table 3-2. This four month survey period forms the basis for the discussion of Calgary's experience with its equipment in this section and the analysis presented in Section 3.3.

The first three columns of Table 3-2 list machine number, the total transactions, and failures for each machine. The next 22 columns show a breakdown of the total failures by failure category. The last column, MCBF or mean cycles between failures, shows a reliability measure for each machine during the survey period. The MCBF measure used by Calgary is computed by dividing transactions by failures, and is equal to the mean transactions between failures, MTF, measure described previously in section 2. The second to last column shows the computed MCBF for a prior (June 1981 to April 1982) survey period for each machine. A breakdown of the data by failure type was not available for this prior period.

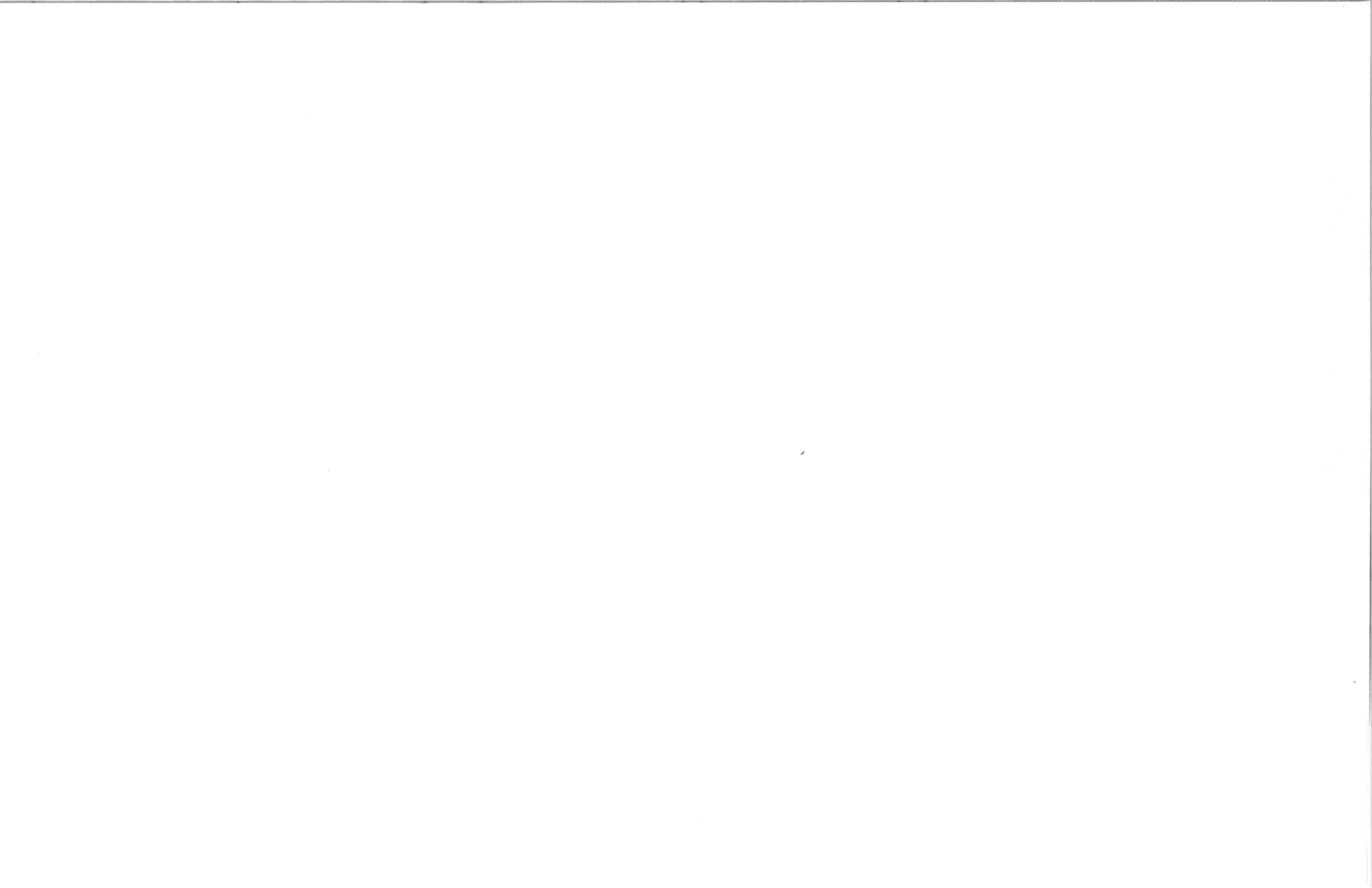
The row labeled TOTALS near the bottom of the chart shows the totals for transactions and failures, and shows the system wide MCBF in the last column. The bottom row labeled "LESS ADMIN" excludes certain failure types and produces a second and more favorable system wide MCBF (the last entry in the last column of Table 3-2). This MCBF reflects a more restricted view of what Calgary considers a true machine failure. Specifically, four columns of failures--PAPER LOW, CASH BOX, REPLACE RIBBON, REPLACE COIN REJECT DISH--have been deducted from the failure count.

Calgary believes that these columns contain failures caused by administrative action or inaction, and do not reflect true machine failures. The PAPER LOW columns reflect the failure to check and replenish the ticket paper stock periodically.



TABLE 3-2  
RAW TRANSACTION AND FAILURE DATA

LINE	TRANS	FAILS	DATA	ACCEPT GATE JAMMED CLOSED	ACCEPT GATE JAMMED OPEN	REJECT GATE CANNOT OPEN	FARE BUTTON	REJECT GATE CANNOT CLOSE	TICKET ISSUE P-CELL FAIL	TICKET STUCK	PAPER ADVANCE DEFECT	COIN TESTER FAIL	PAPER LOW	CASH BOX	SEIKO PRINTER FAIL	CANCEL JAMMED	CANCEL TIME DATE SYNC	REPLACE RIBBON	REPLACE BATTERY	BROKEN KEY	REPLACE COIN ACCEPT	REPLACE COIN REJECT DISH	INPUT BOARD FAIL	REPLACE TICKET DISP UNIT	MCBF JUN 81 MAR 82	MCBF APR 82 JUL 82	
1	74778	22		5						1			5	7		1		3							3152	3561	
2	46240	22		2	3	1			1				3	3		4		2		1					1786	2102	
3	40341	3			1				1				2	2		1		1							2503	5043	
4	24363	14		1	1								3	4	2	2	1								1080	1740	
5	35004	6	1										2			2		1							1697	5834	
6	27937	14		1				1					3	6		1		2							1450	1996	
7	34104	8	1										3	2				2							1584	4263	
8	35384	9		1									3	1		3		1							2333	3932	
9	43054	11								3			5	2				1							2067	3914	
0	21524	11	1	2									3	4				1							461	1957	
1	50623	19		1		1			2	2			7	1		1		3			1				3606	2664	
2	57221	11											6	2				2							3472	5202	
3	11060	22								3			2	2	2	3	1	1					3		686	503	
4	38012	21		4	2			2		1	1		3	1		3		2		1					2071	1810	
5	18999	11		4				1		1			2	1			1		1						655	1727	
6	12905	4								1			1	2											911	3226	
7	11896	3								1		1	1	2											1150	3965	
8	31823	13											4	7				1	1						1217	2448	
9	47695	10											3	4		1		1		1					4051	4770	
0	34676	9											3	4				2							849	3853	
1	24482	9		3									2	2				2							655	2720	
2	11748	10	1							1			2	1		1	3	1							687	1175	
3	9460	5								1					2	2									428	1892	
4	10310	14						1		3				7	1	1									1265	736	
5	27520	10		4									3					1					1	1	1783	2752	
6	42531	20	1		1					3			5	2	1			1		1					2091	2127	
7	22355	14			1					3			2	5	1	1		1		1					1342	1597	
8	41974	23			3				3	2			3	6		2		3			1				2767	1825	
9	54705	15	1	2	1	1				1	1		3	2		1		1					1		3014	3647	
0	39432	13		2	1		1						3		2	1		2			1				2281	3033	
1	38939	6											3	1		1		1							2943	6490	
2	22338	7	1				1		1	1			1			1		1							1644	3191	
3	44126	20	1		2	5				1			4	5				2							1667	2206	
4	31709	18		1						6			3	6				2							1901	1762	
5	29979	6	1	1			1						2	1											2657	4997	
6	8638	8		3			1						3					1							1748	1080	
7	12306	13								6			2	2		2	1								1412	947	
8	24367	12		1						2			2	4	1	1		1							1346	2031	
9	44406	13		1	1				1	2			3	2		1	1	1							2905	3416	
0	17238	11							1	2			1	1	1	2		1		1			1		2567	1567	
1	10058	7		1	1					1		1	2												755	1437	
2																											
	1266260	502	9	40	18	8	4	5	10	58	2	3	113	102	14	41	8	48	5	2	4	3	3	2		2522	
S	ADMIN	234	9	40	18	8	4	5	10	58	2	3			14	41	8		5		4	3	2			5411	



The CASH BOX column covers a variety of problems such as failure to insert an empty cash box during regular cash box pickup, allowing the cash box to become full, or failure to insert the empty cash box correctly. The REPLACE RIBBON column reflects the failure to replace printer ribbons on a preventative maintenance schedule. The BROKEN KEY and REPLACE COIN REJECT DISH columns apparently reflect mishandling by maintenance personnel.

Table 3-2 identified twenty-two failure categories and tabulated the number of failures per category per machine. In Table 3-3, these twenty-two categories are associated with components of the machine, and are then further defined as to type (hard or soft) and down time.

The eight major components of the machine are listed in the COMPONENTS column. Parts within each component that can or have failed are listed below each component. The ERROR CODE column contains the code number of each failure that the machine is capable of detecting itself. Each of the failures except Low Paper and Cash-Box-Nearly-Full cause an "out-of-order" alarm to be communicated by wire to a central monitoring facility where maintenance personnel can be dispatched for repair. Low-Paper and Cash-Box-Nearly--Full conditions communicate separate alarms to the central station.

The FAILURE column gives a very brief indication of the problem or action taken to solve it. A more complete description of the machine detectable failures is listed below.

1. DATA ERROR: Electronic failure (accounting could be affected).
2. COIN ACCEPTOR: Cash box "Acceptor gate" jammed--cannot be opened.
3. COIN ACCEPTOR: Cash box "Acceptor gate" stays open--cannot be closed.
4. COIN ACCEPTOR: Coin return "reject gate" jammed--cannot be opened.
5. COIN ACCEPTOR: Coin return "reject gate" stays open--cannot be closed.
6. Issued ticket from dispensing unit doesn't affect photocell.
7. Issued ticket stuck--cutting device is not sharp enough.
8. Validator missing turns--time or date wrong.

TABLE 3-3  
COMPONENT FAILURES AND DOWN TIME

<u>COMPONENTS</u>	<u>ERROR CODE</u>	<u>FAILURE</u>	<u>TYPE</u>	<u>DIAGNOSE/REPAIR TIME</u>	<u>DOWN TIME</u>	<u>REF. TO TABLE 3-2 COLUMN NUMBER</u>
Electronic Chassis Subassembly	1	data	SOFT	45	75	4
Printer Interface PCB						
Input PCB		replace	HARD	45	75	24
Front Output PCB						
Voltage Monitor PCB						
Output PCB						
Interface PCB						
Processor PCB						
Power Supply (13/24v) PCB						
Coin Acceptor Subassembly		replace	HARD	15	45	22
Acceptor Gate						
	2	jammed open	SOFT	10	40	6
	3	jammed closed	SOFT	10	40	5
Reject Gate						
	4	cannot open	SOFT	10	40	7
	5	cannot close	SOFT	10	40	9
Coin Tester	10	defect	HARD	45	75	13
Ticket Dispenser Subassembly		replace	HARD	40	70	25
Printer	15	defect	HARD	45	75	16
Guillotine	7	stuck	HARD	15	45	11
Paper Advance Unit						
	6	photocell	HARD	40	70	10
	9	defect	HARD	40	70	12
	11	paper low	SOFT	10	40	14
Ribbon Unit		replace	SOFT	10	40	19
Location Stamper						
Dispenser PCB						
Ticket Validator Subassembly		jammed	SOFT	15	45	17
Printer						
Corner Cutter						
Ribbon Unit						
Location Stamper						
Validator PCB	8	sync	SOFT	10	40	18
Front Door Subassembly						
Lock		key broken	HARD	20	50	21
Alarm Switches						
Fare Buttons and Switches		broken	HARD	15	45	8
Coin Return Door and Dish		repair	HARD	40	75	23
Battery and Charger Subassembly		replace	HARD	15	45	20
Battery						
Charger PCB						
Cash Box	12	missing				
	14	full jammed stuck	SOFT	10	40	15
Alarm and Comm. Subassembly						

9. Advance-paper microswitch defective.
10. Coin tester unit failed.
11. Low paper.
12. Cash box missing.
13. Cash box nearly full.
14. Cash box full machine goes out of order.
15. Seiko printer defective.

Error codes 14 and 13 indicating that the cash box is full or nearly full are not yet operational. The Canadian distributor of the XAMAX machines (Automatec Inc. of Montreal) has designed a new alarm and communications PCB that will detect and send codes 13 and 14. Calgary expects that code 13, "nearly full", will eliminate down time because of full cash boxes.

The TYPE column indicates whether a failure is hard or soft. A failure is designated as hard repair only if on-site work exceeds ten minutes or if off-site is needed. One exception is the DATA failure where 45 minutes of on-site time has been estimated for diagnosing the problem, while the corrective action required is usually just the resetting of the machine. This particular failure can often be caused by power surges or electrical noise, or is sometimes indicative of impending hard failures of the printed circuit boards (PCB).

The DIAGNOSE/ REPAIR TIME column indicates the estimated on-site time to diagnose and/or repair each failure. Down time (see DOWN TIME column) for each failure is computed simply by adding an estimated average of 30 minutes of response time to the on-site time.

When a component is replaced and repaired later in the maintenance shop only the actual diagnosis and replacement time on-site is considered as part of down time. This choice was valid during the survey period because the supply of spare parts was sufficient to allow immediate replacement.

The last column of Table 3-3 provides a convenient cross-reference to Table 3-2. The numbers in this column refer to the columns in Table 3-2 that report the same failure.

The transaction and failure data from Table 3-2 was combined with the down time data and hard/soft typing from Table 3-3. The data were then reorganized to group the machines by station and the failures by component. The result of this combining and reorganizing is shown in Table 3-4. The data are listed vertically by station starting with the southern-most suburban station at the top, and proceed downward in the order that stations are encountered traveling into the downtown area. Subtotals of transactions and failures are provided for each station. Average down time for each category of failure is shown in minutes in the row labeled DOWN. The row labeled CMPNT identifies the component within the machine where the failure occurred. The two-letter identifiers are associated with the components as follows:

EC	Electronic Chassis
CA	Coin Acceptor
TD	Ticket Dispenser
TV	Ticket Validator
FD	Front Door
BC	Battery and Charger
CB	Cash Box

The failure is identified as Hard or SOFT in the sixth row labeled TYPE.

With the exception of operating time, Table 3-4 contains all of the raw data necessary to generate the six sets of input data required for performance measurements at the system, station, machine and component levels. The calculation of these statistics and the analysis and interpretation of their significance is presented in the following section.

### 3.3 Calgary Data Analysis and Interpretation

The raw data extracted from maintenance records and estimates obtained from interviews were transformed first into the six sets of input data defined in Section 2 and the six performance measures were computed for the system, station, machine and component levels.

#### 3.3.1 System Performance Measures

The six sets of input data are:

- Total Transactions
- Total Failures
- Total Operational Time
- Total Down Time



TABLE 3-4  
REORGANIZED TRANSACTION AND FAILURE DATA

TYPE DOWN CMPNT	TRANS	FAILS	DATA	INPUT	ACCEPT	ACCEPT	REJECT	REJECT	COIN	REPLACE	SEIKO	REPLACE	REPLACE	TICKET	PAPER	TICKET	PAPER	CANCEL	CANCEL	BROKEN	FARE	REPLACE	REPLACE	CASH		
				BOARD FAIL	GATE JAMMED CLOSED	GATE JAMMED OPEN	GATE CANNOT OPEN	GATE CANNOT CLOSE	TESTER FAIL	COIN ACCEPT	PRINTER FAIL	RIBBON	TICKET DISP UNIT	ISSUE P-CELL FAIL	LOW	STUCK	ADVANCE DEFECT	JAMMED	TIME DATE SYNC	KEY	BUTTON	COIN REJECT DISH	BATTERY	BOX		
				SOFT 75 EC	HARD 75 EC	SOFT 40 CA	SOFT 40 CA	SOFT 40 CA	HARD 75 CA	HARD 45 CA	HARD 75 TD	SOFT 40 TD	HARD 70 TD	HARD 70 TD	SOFT 40 TD	HARD 45 TD	HARD 70 TD	SOFT 45 TV	SOFT 40 TV	HARD 70 FD	HARD 45 FD	HARD 75 FD	HARD 45 BC	SOFT 40 CB		
LOCATION MACHINE																										
ANDERSON	1	74778	22			5							3												7	
	2	46240	22			2	3	1					2	1									1		3	
	3	40341	8				1						1	1											2	
	4	24363	14			1	1												1						4	
	SUBTOTAL	185722	66	0	0	8	5	1	0	0	0	2	6	0	2	13	1	0	10	1	0	0	0	1	16	
SOUTHLAN	5	35004	6	1									1													
	7	34104	8	1									2												2	
	6	27937	14			1		1					2												6	
	SUBTOTAL	97045	28	2	0	1	0	0	1	0	0	0	5	0	0	0	0	0	3	0	0	0	0	0	8	
HERITAGE	8	35384	9			1							1												1	
	9	43054	11										1												2	
	10	21524	11	1		2							1												4	
	SUBTOTAL	99962	31	1	0	3	0	0	0	0	0	0	3	0	0	11	3	0	3	0	0	0	0	0	7	
CHINOOK	11	50623	19			1		1					3												1	
	12	57221	11		1								2												2	
	34	31709	18			1							2												6	
	SUBTOTAL	139553	48	0	1	2	0	1	0	0	1	0	7	0	2	16	8	0	1	0	0	0	0	0	9	
42ND AVE	14	38012	21			4	2		2	1			2												1	
	13	11060	22										1												2	
	SUBTOTAL	49072	43	0	0	4	2	0	2	1	0	2	3	0	0	5	9	1	6	1	0	0	3	1	3	
ERLTON	15	18999	11			4			1																1	
	16	12905	4																						2	
	17	11896	3							1																
	SUBTOTAL	43800	18	0	0	4	0	0	1	1	0	0		0	0	4	3	0	0	1	0	0	0	1	3	
STAMPEDE	21	24482	9			3							2												2	
	18	31823	13										1												7	
	19	47695	10										1												4	
	20	34676	9										2												4	
	SUBTOTAL	138676	41	0	0	3	0	0	0	0	0	0	6	0	0	12	0	0	1	0	1	0	0	1	17	
CITY HAL	22	11748	10	1									1												1	
	23	9460	5										2													
	24	10310	14										1												7	
	25	27520	10										1													
	SUBTOTAL	59038	39	1	1	4	0	0	1	0	1	3	2	1	0	5	5	0	4	3	0	0	0	0	8	
CENTER	29	54705	15	1	1	2	1	1					1												2	
	28	41974	23				3						3												6	
	27	22355	14				1						1												5	
	26	42531	20	1			1						1												2	
	SUBTOTAL	161565	72	2	1	2	6	1	0	0	1	2	6	0	3	13	14	1	4	0	0	0	0	1	15	
3RD ST W	30	39432	13			2	1						2												1	
	31	38939	6										1													
	32	22338	7	1									1												1	
	33	44126	20	1			2	5					2												5	
	SUBTOTAL	144835	46	2	0	2	3	5	0	0	1	2	6	0	1	11	2	0	3	0	0	2	0	0	6	
6TH ST W	35	29779	6	1		1																			1	
	36	8638	8			3							1													
	37	12306	13										1												2	
	38	24367	12			1							1												4	
	SUBTOTAL	75290	39	1	0	5	0	0	0	0	0	1	2	0	0	9	0	0	3	1	0	2	0	0	7	
8TH ST W	39	44406	13			1	1						1												2	
	40	17238	11										1												1	
	41	10058	7			1	1						1													
	SUBTOTAL	71702	31	0	0	2	2	0	0	1	0	2	2	1	2	6	5	0	3	1	1	0	0	0	3	
TOTALS		1266260	502	9	3	40	18	8	5	3	4	14	48	2	10	113	58	2	41	8	2	4	3	5	102	



Total Hard Failures  
Total Down Time (Hard Failures Only)

The transaction and failure data are available directly from Table 3-4. Since Calgary operates the LRT system 20 hours per day, the total operational time of each machine for the 109 day period is 2180 hours. The down times are computed from the data in Table 3-4 by summing the down times for each category of failure. The down time for each category is computed by multiplying the down time per failure shown in the row labeled DOWN, by the number of occurrences of that failure.

These six sets of input data are tabulated by machine in Table 3-5. The right half of Table 3-5 contains the six associated performance measures :

R = Reliability (probability of a successful transaction)  
MTF = Mean Transactions Per Failure  
MTBF = Mean Time Between Failures  
A = Availability  
ADT = Average Down Time  
MTTR = Mean Time to Repair

This table contains a summary by station at the bottom, and system wide data inputs and measures form the last row.

Table 3-6 summarizes the performance measures by component. More detailed tabulations for each component are presented in Appendix A.

The values shown for MTBF and availability at the station and system levels in Tables 3-5 and 3-6 are the average values as defined by the PEP. Table 3-7 compares these average values to two of the three additional statistics defined in Section 2, i.e. the overall MTBF indicating maintenance demands and the full availability measure indicating the probability that all machines at a given station are functional. Table 3-7 does not show the probability that one or more machines will be operational at any time since for all stations this value is greater than 0.999999.

### 3.3.2 Data Interpretation

That the probability of at least one machine being operational at any given station is very near unity indicates Calgary is consistently able to provide its passengers with the means to obtain the required proof-of-payment. Such extremely high

**TABLE 3-5  
SYSTEM PERFORMANCE - CALGARY**

LOCATION	MACHINE	TRANS	OP TIME (HRS)	TOTAL FAILS	TOTAL DOWN TIME (HRS)	TOTAL HARD FAILS	TOTAL DOWN TIME HARD (HRS)	F	MTF	MTBF (HRS)	A	ADT (HRS)	MTTR (HRS)
ANDERSON	1	74778	2180	22	14.83	1	0.75	.999706	3399	99.09	.993176	0.67	0.75
	2	46240	2180	22	15.75	2	1.92	.999524	2102	99.09	.992775	0.72	0.36
	3	40341	2180	6	5.92	1	1.17	.999802	5043	272.50	.997206	0.74	1.17
	4	24363	2180	14	10.67	2	2.50	.999425	1740	155.71	.995107	0.76	1.25
SOUTHLAND	5	35004	2180	6	5.06	0	0.00	.999829	5834	363.33	.997676	0.84	NA
	7	34104	2180	3	6.23	0	0.00	.999715	4743	172.50	.997143	0.78	NA
	6	27937	2180	14	9.42	0	0.00	.999490	1995	155.71	.995680	0.67	NA
HERITAGE	8	35384	2180	9	6.25	0	0.00	.999746	3932	242.22	.997133	0.69	NA
	9	43054	2180	11	7.58	3	2.25	.999745	3914	198.18	.996521	0.69	0.75
	10	21524	2180	11	8.23	0	0.00	.999489	1957	198.18	.996225	0.75	NA
CHINOOK	11	50623	2180	19	13.25	5	4.58	.999625	2664	114.74	.993922	0.70	0.92
	12	57221	2180	11	7.92	1	1.25	.999808	5202	198.18	.996360	0.72	1.25
	34	31709	2180	18	12.50	6	4.50	.999432	1762	121.11	.994266	0.69	0.75
42ND AVE	14	38012	2180	21	14.25	4	3.92	.999446	1810	103.31	.993463	0.65	0.96
	13	11060	2180	22	18.50	13	12.25	.998011	503	99.09	.991514	0.84	0.94
ERLTON	15	18999	2180	11	7.50	2	1.50	.999421	1727	198.18	.996560	0.65	0.75
	16	12905	2180	4	2.75	1	0.75	.999690	3226	545.00	.998739	0.69	0.75
	17	11896	2180	3	1.42	2	2.00	.999748	3965	726.67	.999350	0.47	1.00
STAMPEDE	21	24482	2180	9	6.00	0	0.00	.999632	2720	242.22	.997248	0.67	NA
	18	31823	2180	13	8.75	1	0.75	.999591	2446	167.69	.995986	0.67	0.75
	19	47695	2180	10	7.25	1	1.17	.999790	4769	218.00	.996674	0.72	1.17
	20	34676	2180	9	6.00	0	0.00	.999740	3853	242.22	.997248	0.67	NA
CITY HALL	22	11748	2180	10	7.70	1	0.75	.999149	1175	218.00	.996455	0.77	0.75
	23	9460	2180	5	4.75	3	3.25	.998471	1892	436.00	.997821	0.95	1.08
	24	10310	2180	14	10.75	5	4.67	.998642	736	155.71	.995069	0.77	0.93
	25	27520	2180	10	6.58	2	2.00	.999637	2752	218.00	.996980	0.66	1.00
CENTER	29	54705	2180	15	12.15	3	3.17	.999726	3647	145.33	.994429	0.81	1.06
	28	41974	2180	23	16.50	6	5.75	.999452	1825	94.78	.992431	0.72	0.96
	27	22355	2180	14	10.25	4	3.50	.999374	1597	155.71	.995298	0.73	0.88
	26	42531	2180	20	15.56	10	8.00	.999530	2127	109.00	.992861	0.76	0.80
3RD ST W	30	39432	2180	13	9.30	4	4.00	.999670	3033	167.69	.995719	0.72	1.00
	31	38939	2180	6	4.06	0	0.00	.999846	6490	363.33	.998127	0.68	NA
	32	22338	2180	7	6.31	3	2.67	.999687	3191	311.43	.997104	0.90	0.89
	33	44126	2180	20	14.31	1	0.75	.999547	2206	109.00	.993435	0.72	0.75
6TH ST W	35	29979	2180	6	4.98	1	0.75	.999800	4996	363.33	.997716	0.83	0.75
	36	8636	2180	6	5.42	1	0.75	.999074	1030	272.50	.997515	0.60	0.75
	37	12306	2180	13	9.33	6	4.50	.998044	947	167.69	.995719	0.72	0.75
	38	24367	2180	12	8.83	3	2.75	.999506	2031	131.67	.995946	0.74	0.92
8TH ST W	39	44406	2180	13	9.42	3	2.67	.999707	3416	167.69	.995680	0.72	0.89
	40	17238	2180	11	9.75	6	6.25	.999362	1567	198.18	.995526	0.89	1.04
	41	10058	2180	7	4.67	3	3.25	.999304	1437	311.43	.997859	0.67	1.08
<b>SUMMARY</b>													
ANDERSON		185722	8720	66	47.17	6	6.33	.999645	2814	132.12	.994591	0.71	1.06
SOUTHLAND		97045	6540	28	20.71	0	0.00	.999711	3466	233.57	.996834	0.74	NA
HERITAGE		99962	6540	31	22.06	3	2.25	.999690	3225	210.87	.996627	0.71	0.75
CHINOOK		139553	6540	40	33.67	12	10.33	.999656	2907	136.25	.994852	0.70	0.86
42ND AVE		49072	4360	43	32.75	17	16.17	.999124	1141	101.40	.992489	0.76	0.95
ERLTON		43800	6540	16	11.67	5	4.25	.999539	2433	363.33	.998214	0.65	0.85
STAMPEDE		138676	8720	41	28.00	2	1.92	.999704	3982	212.68	.996789	0.68	0.86
CITY HALL		59038	8720	39	29.81	11	10.67	.999339	1514	223.59	.994581	0.76	0.97
CENTER ST		181565	8720	72	54.46	23	20.42	.999554	2244	121.11	.993755	0.76	0.89
3RD ST W		144835	8720	46	34.04	8	7.42	.999682	3149	189.57	.996096	0.74	0.85
6TH ST W		75290	8720	39	28.56	11	8.75	.999482	1931	223.59	.996724	0.73	0.80
8TH ST W		71702	6540	31	23.83	12	12.17	.999568	2313	210.97	.994356	0.77	1.01
SYSTEM		1266260	89380	502	366.73	110	100.67	.999604	2522	178.05	.995897	0.73	0.92

TABLE 3-6  
SUMMARY OF COMPONENT PERFORMANCE - CALGARY

COMPONENT	TRANS	OP TIME (HRS)	TOTAL FAILS	TOTAL DOWN TIME (HRS)	TOTAL HARD FAILS	TOTAL DOWN TIME HARD (HRS)	R	MTF	MTBF (HRS)	A	ADT (HRS)	MTTR (HRS)
ELECTRONIC CH.	1266260	89380	12	17.81	3	3.75	.999991	105521	7446	.999801	1.48	1.25
COIN ACCEPTOR	1266260	89380	78	47.33	7	6.75	.999938	16234	1146	.999470	0.61	0.96
TICKET DISPENSER	1266260	89380	247	134.67	86	77.33	.999805	5127	362	.997934	0.75	0.90
TICKET VALIDATOR	1266260	89380	49	36.08	0	0.00	.999961	25842	1824	.999596	0.74	NA
FRONT DOOR ASSB.	1266260	89380	9	9.03	9	9.08	.999993	140694	9931	.999898	1.01	1.01
BATT. & CHARGER	1266260	89380	5	3.75	5	3.75	.999996	253248	17376	.999958	0.75	0.75
CASH BOX	1266260	89380	102	68.00	0	0.00	.999919	12414	876	.999239	0.67	NA
SYSTEM	1266260	89380	502	366.72	110	100.66	.999604	2522	178	.995897	0.73	0.92

TABLE 3-7  
CALGARY STATION RELIABILITY AND AVAILABILITY

STATION	MACHINE STATION				DOWN TIME (HRS)	MTBF1 (HRS)	MTBF2 (HRS)	A1	A2
	OP TIME (HRS)	OP TIME (HRS)	FAILS	DOWN TIME (HRS)					
ANDERSON	8720	2180	66	47.17	132.12	33.03	.994591	.978362	
SOUTHLAND	6540	2180	26	20.71	233.57	77.86	.996833	.9905	
HERITAGE	6540	2180	31	22.06	210.97	70.32	.996627	.989681	
CHINOOK	6540	2180	48	33.67	136.25	45.42	.994852	.984555	
42ND AVE	4360	2180	43	32.75	101.40	50.70	.992489	.984977	
ERLTON	6540	2180	18	11.67	363.33	121.11	.998216	.994647	
STAMPEDE	8720	2180	41	28.00	212.68	53.17	.996789	.987156	
CITY HALL	8720	2180	39	29.81	223.59	55.90	.996581	.986326	
CENTER S	8720	2180	72	54.46	121.11	30.28	.993755	.975018	
3RD ST W	8720	2180	46	34.04	189.57	47.39	.996096	.984385	
6TH ST W	8720	2180	39	28.56	223.59	55.90	.996725	.986899	
8TH ST W	6540	2180	31	23.83	210.97	70.32	.996356	.989069	
SYSTEM	89380	2180	502	366.73	178.05	4.34	.995897	.831775	

MTBF1 --- AVERAGE OF THE MTBF'S OF THE MACHINES AT EACH STATION (OR FOR THE SYSTEM)  
 MTBF2 -- MTBF AT A STATION (OR FOR THE SYSTEM)  
 A1 --- AVERAGE OF THE AVAILABILITIES OF THE MACHINES AT EACH STATION (OR FOR THE SYSTEM)  
 A2 --- PROBABILITY THAT ALL MACHINES AT A STATION (OR THE SYSTEM) ARE AVAILABLE

station availability supports the enforcement process since one of the most common means of defrauding the self-service system--the claim that no machine was working--is virtually eliminated. The so-called full-availability measure indicates that the probability of complete satisfaction, from the standpoint that all machines are found to be functioning, is still decidedly good. The passenger finds all machines operational at any given station more than 97 percent of the time. Average availabilities reveal an even greater percentage and indicate a satisfactory level of performance is almost always achieved.

The performance measures in Tables 3-5 and 3-6 seem to suggest the following conclusions:

1. Reliability, in general, appears to improve with higher machine utilization. At Anderson, for example, Machine 1 with approximately three times the number of transactions of Machine 4 exhibits an MTF approximately double that of Machine 4. Table 3-5 contains numerous instances where apparently greater numbers of transactions result in higher values for MTF, i.e., improved reliability.
2. Overall machine reliability is largely determined by the reliability of the components associated with the purchasing of tickets rather than ticket validation. As indicated in Table 3-6, approximately 49 percent of all failures were due to ticket dispenser failures, 20 percent to the cash box, and 16 percent to the coin acceptor. Thus, approximately 75 percent of all failures occurred in components directly related to ticket purchasing while only 10 percent of the failures were directly related to ticket validation. Even though ticket purchases may exceed ticket validations 75 percent to 25 percent, the data indicate the greater reliability of the validator and suggest increased marketing of multi-ride tickets.
3. Machines located in sheltered locations exhibit significantly greater reliability than machines in open locations exposed to the weather. Data in the station summary section of Table 3-5 show consistently higher MTF for machines located in sheltered stations as opposed to open platforms. Table 3-8 summarizes the reliability measures for sheltered versus open machines and shows the differences more clearly.

TABLE 3-8  
RELIABILITY 95% CONFIDENCE INTERVAL - CALGARY

LOCATION	TRANS	FAILS	RELIABILITY			MTF		
			95% CONFIDENCE INTERVAL			95% CONFIDENCE INTERVAL		
			LOW	MEAN	HIGH	LOW	MEAN	HIGH
INSIDE LOCATIONS								
ANDERSON	185722	66	.999555	.999645	.999730	<b>2250</b>	2814	3709
SOUTHLAN	97045	28	.999605	.999711	.999818	2529	3466	5504
HERITAGE	99962	31	.999581	.999690	.999799	2385	3225	4976
CHINOOK	139553	48	.999559	.999656	.999753	2266	2907	4054
ERLTON	43800	18	.999399	.999589	.999779	1665	2433	4522
STAMPEDE	138676	41	.999614	.999704	.999795	2590	3382	4674
TOTAL	704758	232	.999685	.999671	.999713	3177	3008	3486
OUTSIDE LOCATIONS								
42ND AVE	49072	43	.998862	.999124	.999386	879	1141	1627
CITY HAL	59038	39	.999132	.999339	.999547	1152	1514	2206
CENTER S	161565	72	.999451	.999554	.999657	1823	2244	2918
3RD ST W	144835	46	.999591	.999682	.999774	2443	3149	4428
6TH ST W	75290	39	.999319	.999482	.999645	1469	1931	2813
8TH ST W	71702	31	.999415	.999568	.999720	1711	2313	3569
TOTAL	561502	270	.999462	.999519	.999576	1858	2080	2361
SYSTEM	1266260	502	.999609	.999604	.999638	2557	2522	2764



One must recognize, however, that each of these three possible conclusions have been based on independent observations from the data. Inter-dependencies within the data could combine to make one or more of the conclusions invalid. For example, higher reliability with higher machine utilization may not be the result of any machine characteristic but due to a combination of where the machine is located and how it is used. The three major variables having the greatest impact on the conclusions are:

- a. sheltered versus open environment.
- b. machine utilization--high versus low ticket validation percentage of total transactions.
- c. overall machine utilization--high versus low total transactions.

Other variables such as higher incidences of vandalism at certain stations could have an impact, but cannot be judged given the level of detail of the data available.

Table 3-8 summarizes the analysis performed for machines in sheltered versus open locations. Confidence intervals for each station and each group are presented and the results indicate that there is indeed a significant difference in performance depending on the location of the machines.

Data providing a breakdown of total transactions into ticket purchasing transactions and ticket validation transactions was not available for the survey period. Consequently, the second conclusion, i.e., that machines with higher percentages of ticket validations exhibit better overall performance, cannot be investigated in detail. However, such data was available for a three day period in October 1982 and it could be assumed that similar percentages applied during the survey period. Table 3-9 compares the MTF of four machines having relatively high percentages of ticket validations with three machines having relatively low percentages. All seven machines are located on open platforms. In general, the machines with higher validation percentages exhibit higher reliability. While there does appear to be general confirmation, the lack of data specific to the survey period prevents a definite conclusion, and additional data are required to validate this observation. If subsequent analysis did verify this conclusion, it would indicate that greater emphasis should be given to the promotion of multi-trip

tickets not only because it coincides with the general philosophy of self-service, but because of increased equipment reliability.

The observation that equipment reliability may actually improve with greater machine utilization is the most difficult to confirm. The data in Table 3-5 suggest that this is the case, and the breakdown provided in Table 3-9 indicates that this would be true not only for the overall machine but within each machine function as well. Insufficient data exists in the Calgary case, however, and this conclusion cannot be confirmed. This phenomena also arises in Edmonton (Section 4), and will be discussed in more detail in that section since data inter-dependencies are less prominent in the Edmonton equipment.

TABLE 3-9  
VALIDATION EFFECT ON SYSTEM PERFORMANCE

<u>Machine Number</u>	<u>Total Transactions</u>	<u>Percent Validations</u>	<u>Total Validations</u>	<u>MTF Overall</u>	<u>MTF Validator</u>	<u>MTF Ticket Vending</u>
<u>High Percentage of Validations</u>						
31	38,939	60	23,363	6,490	23,363	3,115
33	44,126	35	15,444	2,206	NA	1,434
35	29,979	34	10,193	4,997	NA	3,298
38	24,367	43	10,478	<u>2,031</u>	<u>10,478</u>	<u>1,263</u>
Total	<u>137,411</u>		<u>59,478</u>			
AVG. MTF				3,123	29,739	1,856
<u>Low Percentage of Validations</u>						
14	38,012	10	3,801	1,810	1,267	1,901
13	11,060	6	664	503	166	578
25	27,520	2	550	<u>2,752</u>	<u>NA</u>	<u>2,647</u>
Total	<u>76,592</u>		<u>5,015</u>			
AVG. MTF				1,445	716	1,556



#### 4. EDMONTON ASSESSMENT

##### 4.1 Edmonton Transit System

The city of Edmonton in the Alberta province of Canada provides mass transit service to its population of over 500,000 people through its Edmonton Transit Department. The fleet of 664 buses and 137 trolley buses uses conventional fareboxes. The seventeen\* car Light Rail Transit (LRT) system, which has been in operation since April 23, 1978, now uses a Self-Service Fare Collection (SSFC) system. The SSFC equipment consists of 40 ticket vending machines manufactured for Edmonton by Duncan Industries of Chicago, Illinois. Originally these machines were part of a barrier and fare agent system that was abandoned in 1980 in favor of the less expensive SSFC system. Most machines still have a tripod turnstile. However, these are now free-wheeling and are no longer controlled by the deposit of the correct fare.

The forty ticket machines are located inside the six LRT stations along a 9.4 kilometer (5.8 mile) right-of-way that starts in the northwest Clareview subdivision and terminates downtown at the Central Station on 101st Street and Jasper Avenue. The map in Figure 4 shows the location of the stations as heavy bold blocks. The two downtown stations (Central and Churchill) are underground, and are connected via an underground pedestrian walkway (Pedway) to many of the major buildings along Jasper Avenue. The remainder of the right-of-way is at grade level with a few gate protected crossings for street traffic.

There are two types of machines. Thirty-four machines have turnstiles and were part of the old barrier system. Six of the machines (one per station) do not have turnstiles. They were installed when the system was converted to SSFC and are used to accommodate passengers in wheelchairs. Most of these latter machines are away from the general flow of passengers and consequently vend far fewer tickets than the turnstile machines. The distribution of machines by station, machine number and type is shown in Table 4-1. Note that three of the stations have two separate entrances with a group of machines assigned to each.

Both types of machines were assembled by Duncan Industries using for the most part standard modules from their Transentry Turnstile product line. There are six major components in the machines for which data have been collected. These components are listed below along with the Duncan module name where applicable.

\*Will expand to 37 LRT vehicles before the end of 1983.

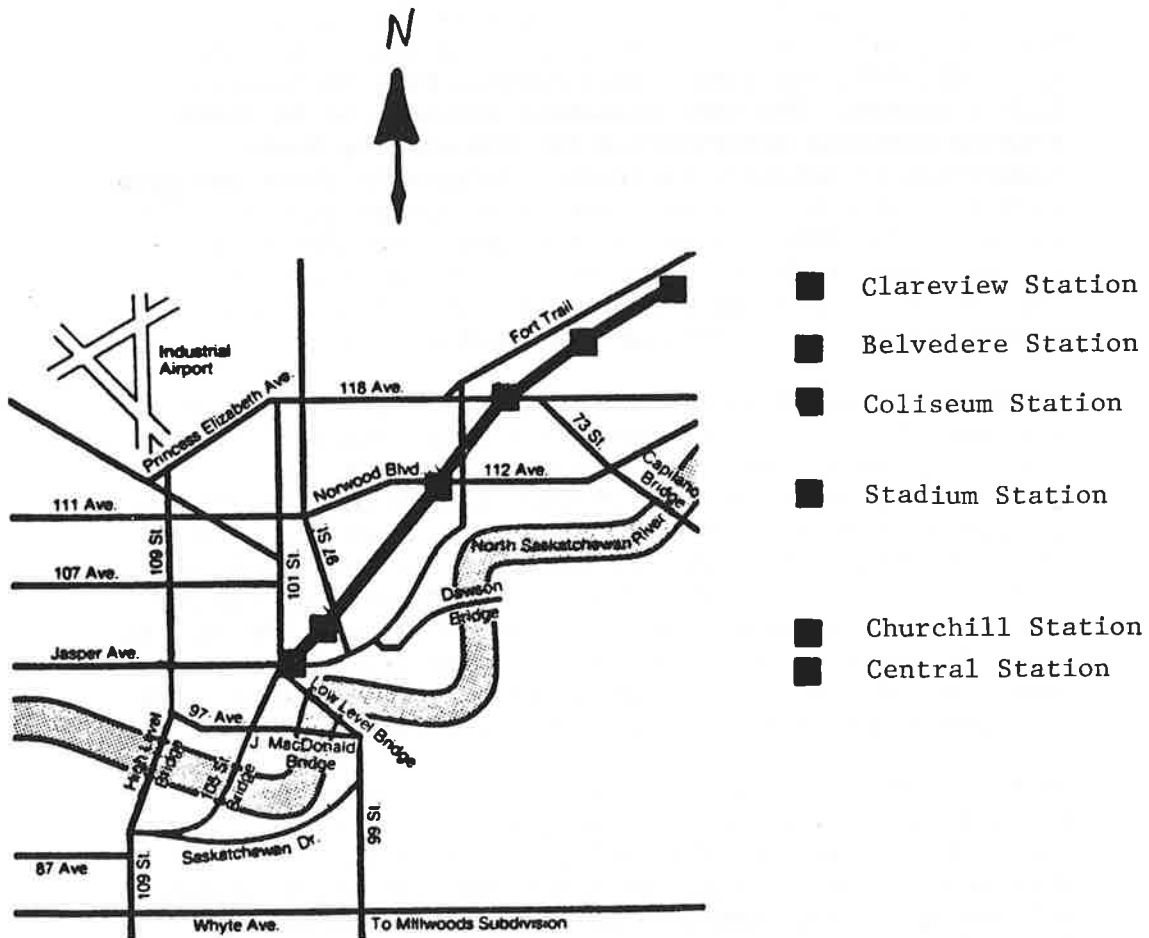


FIGURE 4  
EDMONTON LRT ROUTE AND STATIONS

TABLE 4-1  
DISTRIBUTION OF EDMONTON TICKET MACHINES

STATION	MACHINE NUMBERS*						
	NO TURNSTILE	WITH TURNSTILE					
Central							
West		1383	1398	1388	1412		
East	1423	1402	1393	1417	1418		
Churchill							
South	1424	1405	1385	1410			
North		1403	1419	1384			
Stadium	1425	1395	1381	1396	1407	1386	1390
Coliseum							
North	1422	1382	1887	1394	1401	1400	1391
South		1415	1413				
Belvedere	1421	1404	1409				
Clareview	1420	1406	1389	1397	1392		

\*Machine numbers are referenced in the order of their location within each station.

<u>Component</u>	<u>Duncan Module Name</u>
Electronic Chassis	Electronic Logic Chassis
Coin Mechanism	Coin Mechanism
Ticket Dispenser	Transfer Issue Machine
Cash Storage Subsystem	
Escrow Unit	Coin Escrow Unit
Cash Vault	Securafare Unit
Electrical Subsystem	
Heaters, Fans, Sensor,	Environmental Control Unit
Controls	
Power Supply	
Lamps	
Turnstile	Head Mechanism

A drawing of the ticket machine with turnstile is shown in Figure 5. The ticket dispenser and supply of ticket stock are located at the far left end, i.e., after passing through the turnstile. The non-turnstile machine can be visualized by removing the center section from the machine in Figure 5 and placing the two ends side by side with the ticket dispensing slot on the right facing in the same direction as the coin escrow window. The coin mechanism is located on top of the coin escrow/cash vault side of the machine.

The electronic chassis contains two printed circuit boards (PCB) that interface with and control other components of the machine. The coin mechanism accepts coins, tests coin diameters optically, counts Canadian one-cent, five-cent, ten-cent, twenty-five-cent, and fifty-cent coins, and can accept a token should one be authorized in the future. The ticket dispenser prints, cuts, and dispenses proof-of-purchase receipts (POP tickets) from a fan-fold stack of preprinted ticket stock (see Figure 6). The escrow unit retains coins in a chamber which is visible to the passenger through a plastic window until the correct amount of coins (or more) have been deposited. The unit then drops the coins into the cash vault.\* There is no coin return mechanism. The electrical subsystem maintains the temperature and humidity within the machine, provides DC power, and illuminates the display window. The turnstile is now free-wheeling, and failure data are no longer collected for it.

\*The actual drop takes place when the next passenger deposits the correct fare, so the escrow window always contains coins. Edmonton has recently covered the escrow window because some passengers caught without a "proof-of-payment" receipt were claiming that they had deposited their money but the machine did not dispense a receipt, and they would try to convince the fare inspector that the coins visible in the escrow window were deposited by them.



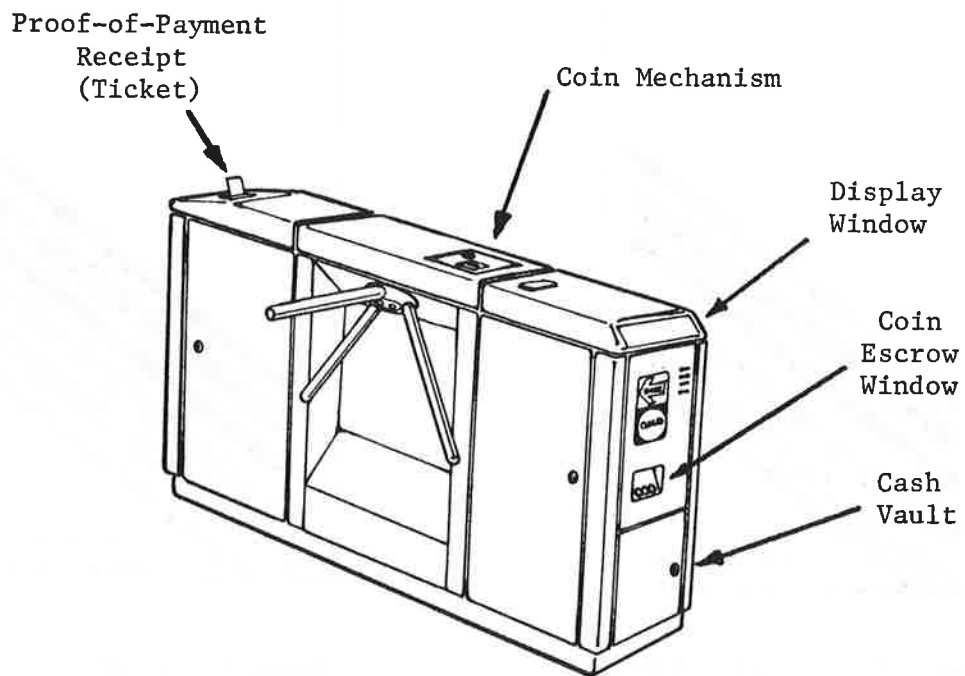
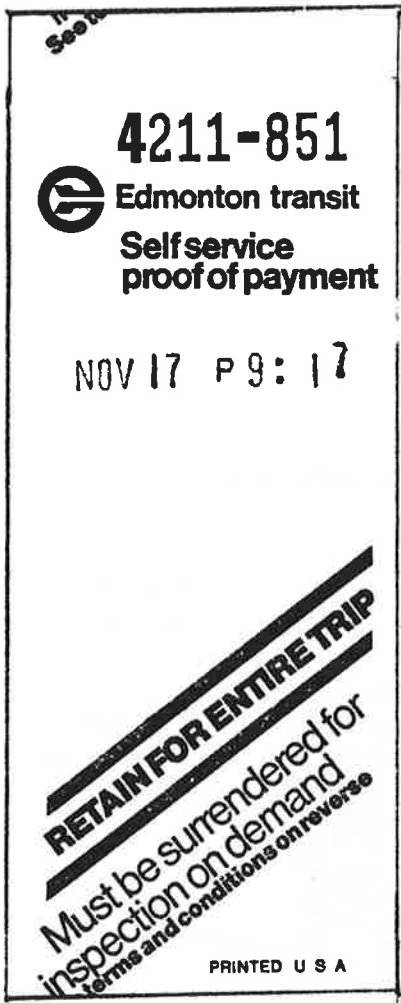
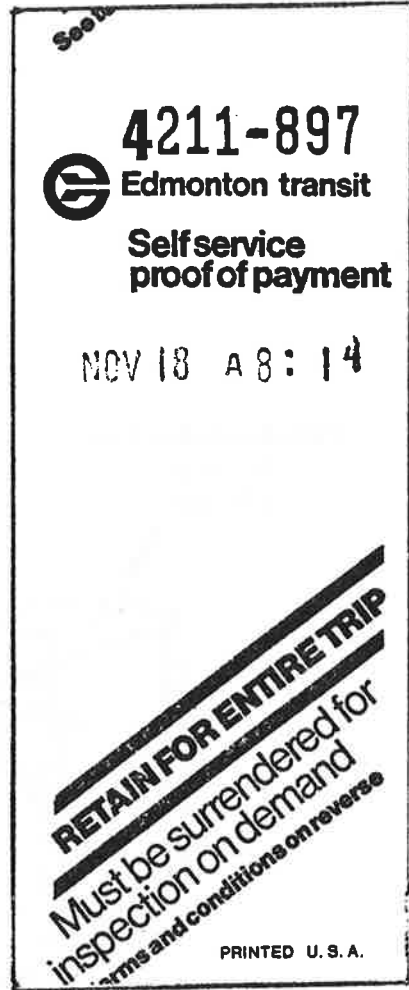


FIGURE 5  
EDMONTON TICKET MACHINE (WITH TURNSTILE)



Date: November 17, 1982  
Time: 9:17 P.M.



Date: November 18, 1982  
Time: 8:14 A.M.

FIGURE 6  
PROOF-OF-PAYMENT TICKET

## 4.2 Edmonton Data Collection

Edmonton records transaction and failure data for each machine chronologically as failures occur. These initial records are handwritten with a brief description of each failure and its date of occurrence. Each month these handwritten records are reviewed, the failures are categorized, and a one-page report in memorandum form is published that lists the totals for five failure categories for all machines taken together.

The five categories reported by Edmonton are:

- Electronic
- Coin Mechanism
- Printer (Ticket Dispenser)
- Electrical
- Miscellaneous

Outside of the handwritten records there is no breakdown of failures by machine or station, so these records were reviewed, and the failures were assigned to eleven categories that distinguish between hard and soft failures and between failures that required different amounts of time to diagnose and repair (or replace). These eleven failures are listed in Table 4-2 along with the components they affect and the down time associated with each. Down time shown in the DOWN TIME column is equal to an estimate average response time of 30 minutes plus the time (in minutes) shown in the DIAGNOSE/REPAIR TIME column. The KEY column contains a cross-reference indicator that will be used with tables in the rest of this section to identify the failure.

Maintenance records for the months of July, August and September of 1982 were reviewed and the failures were categorized and tabulated in Tables 4-3 to 4-6. Tables 4-3, 4-4, and 4-5 contain the failures for July, August, and September, respectively. Table 4-6 contains failures for all three months summed together. Data has been shown and processed for each month separately because the number of transactions in July is more than ten times greater than either August or September. This dramatic increase occurs every July during Edmonton's Klondike Days. The first two columns in these tables identify the station and machine number. The remaining eleven columns contain the number of failures per machine by category. The heading for each of the failure columns indicates whether the failure is hard or soft, the amount of associated down time in minutes, and a key such as EC-S that associates the failure with a particular component of the machine and with the failure categories defined in Table 4-2.

TABLE 4-2  
COMPONENT FAILURE AND DOWN TIME

<u>COMPONENTS FAILURE</u>	<u>TYPE</u>	<u>DIAGNOSE/ REPAIR TIME(Min)</u>	<u>DOWN TIME (Minutes)</u>	<u>KEY</u>
<u>Electronic Chassis</u>				
Unexplained Error (Diagnose & Reset)	SOFT	10	40	EC-S
PCB Failure	HARD	30	60	EC-H
<u>Coin Mechanism</u>				
Jammed (paper)	SOFT	10	40	CM-S
Adjustments required or coins jammed (no paper)	HARD	20	50	CM-H1
Parts replacement required	HARD	10	40	CM-H2
<u>Ticket Dispenser</u>				
Jammed	SOFT	10	40	TD-S
Parts replacement required	HARD	30	60	TD-H
<u>Cash Storage</u>				
Coin escrow unit or cash vault jammed	HARD	10	40	CS-H
<u>Electrical Subsystem</u>				
Replace heaters, fans, sensors, or controls, and power supply parts	HARD	30	60	ES-H1
Replace lamps	HARD	10	40	ES-H2
<u>Miscellaneous</u>	HARD	30	60	MS-H

TABLE 4-3  
JULY TRANSACTIONS AND FAILURES

JUL 82	TYPE->	SOFT	SOFT	SOFT	HARD	HARD	HARD	HARD	HARD	HARD	HARD	HARD	
STATION	MACHINE	DOWN->	40	40	40	60	50	40	60	40	60	40	60
		CMPNT->	EC-S	CM-S	TD-S	EC-H	CM-H1	CM-H2	TD-H	CS-H	ES-H1	ES-H2	MS-H
		TRANS											
CENTRAL	WEST	1383 133453		3	24			1				1	
		1398 133008		2	21		1					2	
		1398 49470			5			1					
		1412 57158			11								
CENTRAL	EAST	1402 95845		4	14		1					1	
		1393 38065		1	5			3					
		1417 56785			3							1	
		1418 109959		2	9								
		1423 5998		1	1							1	1
CHURCHILL	SOUTH	1405 36695			3		1						
		1385 57459		3	5							1	1
		1410 99789		1	5		1	1	1				
		1424 11061			3		1						
CHURCHILL	NORTH	1403 31722			1		1						1
		1419 49974		1	1								
		1384 114977		5	10				1				
STADIUM		1395 76432		2	6							1	
		1381 56317			3				3				
		1396 40380		2	2		1						
		1407 39979			2								1
		1386 22759		2	6							1	
		1390 48384		1	4				1				
		1425 4269		2								1	1
COLISEUM	NORTH	1382 69268			8			2				1	
		1387 53948		1	8							1	
		1394 58751			3		1					1	
		1401 75012		3	4				1	1			
		1400 62648		3	5								
		1391 128058		10	10		1	1		2		1	
		1422 24038										1	
COLISEUM	SOUTH	1415 1355		1	2								
		1413 12679			2							1	
BELVEDERE		1404 168416		2	14				1				1
		1409 144103	1	5	9							1	
		1421 51537		4	7								2
CLAREVIEW		1406 23428		4	9		2					1	
		1389 39857		2	4			1				1	
		1397 70482		4	12		1					1	
		1392 90103		9	6								
		1420 4292		1	1								
SUMMARY													
CENTRAL		679741	0	13	93	0	2	5	0	0	0	6	1
CHURCHILL		401677	0	10	28	0	4	1	2	0	0	1	2
STADIUM		289520	0	9	23	0	1	3	1	0		3	2
COLISEUM		485757	0	18	42	0	2	3	1	3	0	6	0
BELVEDERE		364056	1	11	30	0	0	0	1	0		1	3
CLAREVIEW		228162	0	20	32	0	3	1	0	0		3	0
SYSTEM		2447913	1	81	248	0	12	13	5	3		20	8

TABLE 4-4  
AUGUST TRANSACTIONS AND FAILURES

AUG 82	TYPE->	SOFT	SOFT	SOFT	HARD	HARD	HARD	HARD	HARD	HARD	HARD	HARD		
STATION	MACHINE	DOWN->	40	40	40	60	50	40	60	40	60	40		
		CMPT->	EC-S	CM-S	TI-S	EC-H	CM-H1	CM-H2	TD-H	CS-H	ES-H1	ES-H2	MS-H	
		TRANS												
CENTRAL	WEST	1383	12007		5	12			1	1				
		1398	10855		5	10		1		1				
		1388	4231		1	2		2						
		1412	3847		1	3		1				1	1	
CENTRAL	EAST	1402	6217		1	3		2		1		1		
		1393	2429		1	3				1				
		1417	4053			3						2		
		1418	7391			4							1	
		1423	416											
CHURCHILL	SOUTH	1405	2209									1		
		1385	3685			5						1		
		1410	6501			2								
		1424	820		1	1								
CHURCHILL	NORTH	1403	1988			2								
		1419	4198			1								
		1384	8014			8							1	
STADIUM		1395	6185		2	4		1						
		1381	4930		1	2		1						
		1396	3788		1	2								
		1407	3499		1	1		1					2	
		1386	2297		3	2								
		1390	3321		2	2						1		
		1425	273		1					1				
COLISEUM	NORTH	1382	2677		1	3						1		
		1387	1447											
		1394	1130		3	2				1		1	1	
		1401	1905			5		1			1		1	
		1400	2415		2	2		1	1				1	
		1391	5531		2	5		1					1	
		1422	810		1					1				
COLISEUM	SOUTH	1415	574											
		1413	569		2									
BELVEDERE		1404	13220		2	9						1		
		1409	10966		2	7		2	2					
		1421	3660		1	4	5		1	1				
CLAREVIEW		1406	1612		1			1			1			
		1389	3019		3	5		1				1		
		1397	6181		1	3								
		1392	5816		1	2	7	2		1			1	
		1420	137		1			3	1		1		1	
SUMMARY														
CENTRAL		51446		0	14	40	0	5	1	1	4	0	4	2
CHURCHILL		27415		0	1	19	0	0	0	0	0	0	2	1
STADIUM		24293		0	11	13	0	1	2	0	1	0	1	2
COLISEUM		17058		0	11	17	2	2	2	0	2	1	2	7
BELVEDERE		27846		1	8	21	1	2	2	1	1	0	1	0
CLAREVIEW		16765		2	7	15	2	5	1	0	1	2	1	2
SYSTEM		164823		3	52	125	5	15	8	2	9	3	11	14

TABLE 4-5  
SEPTEMBER TRANSACTIONS AND FAILURES

SEP 82	TYPE->	SOFT	SOFT	SOFT	HARD	HARD	HARD	HARD	HARD	HARD	HARD	HARD		
STATION	MACHINE	DOWN->	CM-S	TD-S	EC-H	CM-H1	CM-H2	TD-H	CS-H	ES-H1	ES-H2	MS-H		
	CMPNT->	40	40	40	60	50	40	60	40	60	40	60		
	TRANS	EC-S	CM-S	TD-S	EC-H	CM-H1	CM-H2	TD-H	CS-H	ES-H1	ES-H2	MS-H		
CENTRAL	WEST	1383	10948	6	12		1	2			1			
		1398	9246	4	14						1			
		1388	2931	1	3						1	1		
		1412	3264	4	3						1			
CENTRAL	EAST	1402	5247	2	3			1	1	1	1	1		
		1393	1535	2	2						1			
		1417	3852		3						2			
		1418	6106	2	3	3	1				1	1		
		1423	317								1			
CHURCHILL	SOUTH	1405	1939	2	3		1			1				
		1385	2986	1	7						1			
		1410	5797	1	6									
		1424	751		1									
CHURCHILL	NORTH	1403	1805											
		1419	2686	1							1			
		1384	7939	1	4									
STADIUM		1395	5140	1	10				1		1			
		1381	3791	1	2						1			
		1396	2755	1	2		1				2			
		1407	2476	3	3						2			
		1386	1548	2	1							1		
		1390	2803	4	2		2			1	1	2		
		1425	254	1							1			
COLISEUM	NORTH	1382	3640	2	1			1						
		1387	2013									1		
		1394	1724	3	2			1						
		1401	2658	3	4		1			1				
		1400	2589	3	4	2		1						
		1391	5759	1	4							1		
		1422	812		3									
COLISEUM	SOUTH	1415	673											
		1413	563		2						1			
BELVEDERE		1404	10850	3	2			2		1				
		1409	10439	1	6									
		1421	2611	2	4									
CLAREVIEW		1406	1121	5	2									
		1389	2363	4	2									
		1397	4114	1	2						1			
		1392	6067	3	5				1	1	1			
		1420	109	5	2						1			
SUMMARY														
CENTRAL		43446		1	21	43	3	2	3	1	1	0	9	3
CHURCHILL		23903		0	6	21	0	1	0	1	0	1	2	0
STADIUM		18767		0	13	20	0	3	0	1	0	8	3	3
COLISEUM		20436		1	15	18	2	1	3	0	0	1	1	2
BELVEDERE		23900		2	8	15	0	2	2	0	0	1	0	0
CLAREVIEW		13774		1	26	13	0	0	0	1	1	3	0	0
SYSTEM		144226		5	89	130	5	9	8	3	3	4	23	8

TABLE 4-6  
JULY TO SEPTEMBER TRANSACTIONS AND FAILURES

JUL-SEP	1982	TYPE->	SOFT	SOFT	SOFT	HARD	HARD	HARD	HARD	HARD	HARD	HARD	HARD
STATION	MACHINE	DOWN->	40	40	40	60	50	40	60	40	60	40	60
		CMPNT->	EC-S	CM-S	TD-S	EC-H	CM-H1	CM-H2	TD-H	CS-H	ES-H1	ES-H2	MS-H
		TRANS											
CENTRAL	WEST	1383 156408		14	48		1	3	1	1		2	
		1398 153109		11	45		1	1		1		3	1
		1388 56632	1	2	10		2	1				1	
		1412 64269		5	17		1					2	1
CENTRAL	EAST	1402 107309		7	20		3	1	1	2		3	1
		1393 42029		4	10			3		1		1	
		1417 64690			9							5	
		1418 123456		4	16	3	1					1	2
		1423 6731		1	1							1	1
CHURCHILL	SOUTH	1405 40843		2	6		2		1		1	1	
		1385 64130		4	17							3	1
		1410 112087		2	13		1	1	1				
		1424 229692		1	5		1						
CHURCHILL	NORTH	1403 35515			3		1						1
		1419 56858		2	2							1	1
		1384 130930		6	22					1			1
STADIUM		1395 87757		5	20		1		1			2	
		1381 65038		2	7			4				1	
		1396 46923		4	6		2					2	
		1407 45954		4	6			1				2	4
		1386 26604		7	9							1	2
		1390 54508		7	8		2		1	1		2	
		1425 4796		4						1		2	1
COLISEUM	NORTH	1382 75585		3	12			3				2	
		1387 57408		1	8							1	4
		1394 61605		6	7		1	1		1		2	1
		1401 79575		6	13		2	1	1	1	2		1
		1400 67652		8	11	3	1	2		2			1
		1391 139348	1	16	17	1	1	1				1	1
		1422 25660		1	3					1		1	1
COLISEUM	SOUTH	1415 2602		1	4							2	
		1413 13816		2	2								
BELVEDERE		1404 192486		7	25			2	1		1	1	1
		1409 165508	1	8	22		4	2				1	
		1421 57806	3	12	19	1			1	1			2
CLAREVIEW		1406 26161	1	9	11		3				1	1	
		1389 45239		9	11		1	1				3	
		1397 80777	1	14	17		1				1	2	
		1392 101986	1	14	18	2				2		1	1
		1420 4538		7	3		3	1			1		1
SUMMARY													
CENTRAL		774633	1	48	176	3	9	9	2	5	0	19	6
CHURCHILL		670055	0	17	68	0	5	1	3	0	1	5	3
STADIUM		331580	0	33	56	0	5	5	2	2	0	12	7
COLISEUM		523251	1	44	77	4	5	8	1	5	2	9	9
BELVEDERE		415802	4	27	66	1	4	4	2	1	1	2	3
CLAREVIEW		258701	3	53	60	2	8	2	0	2	3	7	2
SYSTEM		2974022	9	222	503	10	36	29	10	15	7	54	30



### 4.3 Edmonton Data Analysis and Interpretation

The reaw data extracted from maintenance records and estimates obtained from interviews were transformed first into the six sets of input data defined in Section 2 and the six performance measures were computed for the system, station, machine, and component levels. Three survey periods (July, August, and September 1982) were used plus an aggregate of the three months.

#### 4.3.1 System Performance Measures

The six sets of input data are:

- Total Transactions
- Total Failures
- Total Operational Time
- Total Down Time
- Total Hard Failures
- Total Down Time (Hard Failures Only)

The transaction and failure data are available directly from Tables 4-3 to 4-6. Since Edmonton operates its LRT system 20 hours per day, the total operational times for the three periods are 20 times 31, and 30 days respectively. The down times are computed from the data in Tables 4-3 to 4-6 by summing the down times for each category of failure. The down time for each category is computed by multiplying the down time per failure, shown in the row labeled DOWN, by the number of occurrences of the failure.

These six sets of input data are tabulated by machine for the three survey periods (plus aggregate) in the left half of Tables 4-7 to 4-10. The right half contains the following six associated performance measures:

- R = Reliability (probability of a successful transaction)
- MTF = Mean Transactions Per Failure
- MTBF = Mean Time Between Failures
- A = Availability
- ADT = Average Down Time
- MTTR = Mean Time to Repair

Note that these tables contain a summary by station at the bottom, and that system-wide data inputs and measures form the last row.

A summary of input data and performance measures by component is tabulated in Table 4-11 for the combined July to September

TABLE 4-7  
JULY PERFORMANCE - EDMONTON

		JUL 82		OP	DOWN	HARD	HARD		MTBF	MTBF	ADT	MTTR		
		TRANS	FAILS	TIME	TIME	FAIL	DOWN	R	(HRS)	(HRS)	(HRS)	(HRS)		
				(HRS)	(HRS)		TIME							
							(HRS)							
CENTRAL	WEST	1383	133453	29	620	19.33	2	1.37	.99978	4602	21.38	.96882	0.67	0.67
		1398	133008	26	620	17.50	3	2.17	.99980	5116	23.85	.97177	0.67	0.72
		1388	49470	6	620	4.00	1	0.67	.99988	8245	103.33	.99355	0.67	0.67
		1412	57158	11	620	7.33	0	0.00	.99981	5196	56.36	.98817	0.67	NA
CENTRAL	EAST	1402	95845	20	620	13.50	2	1.50	.99979	4792	31.00	.97823	0.68	0.75
		1393	38065	9	620	6.00	3	2.00	.99976	4229	68.89	.99032	0.67	0.67
		1417	56785	4	620	2.67	1	0.67	.99993	14196	155.00	.99570	0.67	0.67
		1418	109959	11	620	7.33	0	0.00	.99990	9996	56.36	.98817	0.67	NA
		1423	5998	4	620	3.00	2	1.67	.99933	1499	155.00	.99516	0.75	0.83
CHURCHILL	SOUTH	1405	36695	4	620	2.83	1	0.83	.99989	9174	155.00	.99543	0.71	0.83
		1385	57459	10	620	7.00	2	1.67	.99983	5746	62.00	.98871	0.70	0.83
		1410	99789	9	620	6.50	3	2.50	.99991	11088	68.89	.98952	0.72	0.83
		1424	11061	4	620	2.83	1	0.83	.99964	2765	155.00	.99543	0.71	0.83
CHURCHILL	NORTH	1403	31722	3	620	2.50	2	1.83	.99991	10574	206.67	.99597	0.83	0.92
		1419	49974	2	620	1.33	0	0.00	.99996	24987	310.00	.99785	0.67	NA
		1384	114977	16	620	11.00	1	1.00	.99986	7186	38.75	.98226	0.69	1.00
STADIUM		1395	76432	9	620	6.00	1	0.67	.99988	8492	68.89	.99032	0.67	0.67
		1381	56317	6	620	4.00	3	2.00	.99989	9386	103.33	.99355	0.67	0.67
		1396	40380	5	620	3.50	1	0.83	.99988	8076	124.00	.99435	0.70	0.83
		1407	39979	3	620	2.33	1	1.00	.99992	13326	206.67	.99624	0.78	1.00
		1386	22759	9	620	6.00	1	0.67	.99960	2529	68.89	.99032	0.67	0.67
		1390	48384	6	620	4.33	1	1.00	.99988	8064	103.33	.99301	0.72	1.00
		1425	4269	4	620	3.00	2	1.67	.99906	1067	155.00	.99516	0.75	0.83
COLISEUM	NORTH	1382	69268	11	620	7.33	3	2.00	.99984	6297	56.36	.98817	0.67	0.67
		1387	53948	10	620	6.67	1	0.67	.99981	5395	62.00	.98925	0.67	0.67
		1394	58751	5	620	3.50	2	1.50	.99991	11750	124.00	.99435	0.70	0.75
		1401	75012	9	620	6.33	2	1.67	.99988	8335	68.89	.98978	0.70	0.83
		1400	62648	10	620	6.67	2	1.33	.99984	6265	62.00	.98925	0.67	0.67
		1391	128058	23	620	15.50	3	2.17	.99982	5568	26.96	.975	0.67	0.72
	1422	24038	1	620	0.67	1	0.67	.99996	24038	620.00	.99892	0.67	0.67	
COLISEUM	SOUTH	1415	1355	3	620	2.00	0	0.00	.99779	452	206.67	.99677	0.67	NA
		1413	12679	3	620	2.00	1	0.67	.99976	4226	206.67	.99677	0.67	0.67
BELVEDERE		1404	168416	18	620	12.67	2	2.00	.99989	9356	34.44	.97957	0.70	1.00
		1409	144103	16	620	10.67	1	0.67	.99989	9006	38.75	.98280	0.67	0.67
		1421	51537	13	620	9.33	2	2.00	.99975	3964	47.69	.98495	0.72	1.00
CLAREVIEW		1406	23428	16	620	11.00	3	2.33	.99932	1464	38.75	.98226	0.69	0.78
		1389	39857	8	620	5.33	2	1.33	.99980	4982	77.50	.99140	0.67	0.67
		1397	70482	18	620	12.17	2	1.50	.99974	3916	34.44	.98038	0.68	0.75
		1392	90103	15	620	10.00	0	0.00	.99983	6007	41.33	.98387	0.67	NA
		1420	4292	2	620	1.33	0	0.00	.99953	2146	310.00	.99785	0.67	NA
SUMMARY														
CENTRAL		679741		120	5580	80.67	14	10.00	.99982	5665	46.50	.98554	0.67	0.71
CHURCHILL		401677		48	4340	34.00	10	8.67	.99988	8368	90.42	.99217	0.71	0.87
STADIUM		288520		42	4340	29.17	10	7.83	.99985	6870	103.33	.99328	0.69	0.78
COLISEUM		485757		75	5580	50.67	15	10.67	.99985	8477	74.40	.99092	0.68	0.71
BELVEDERE		364056		47	1860	32.67	5	4.67	.99987	7746	39.57	.98244	0.70	0.93
CLAREVIEW		228162		59	3100	39.83	7	5.17	.99974	3867	52.54	.98715	0.68	0.74
SYSTEM		2447913		391	24800	267.00	61	47.00	.99984	6261	63.43	.98923	0.68	0.77

TABLE 4-8  
AUGUST PERFORMANCE - EDMONTON

AUG 82		TRANS	FAILS	OP TIME (HRS)	DOWN TIME (HRS)	HARD FAIL	HARD DOWN TIME (HRS)	R	MTF	MTBF (HRS)	A	ADT (HRS)	MTTR (HRS)
CENTRAL WEST	1383	12007	19	620	13.00	2	1.67	.99842	632	32.63	.97903	0.68	0.83
	1398	10855	17	620	11.33	2	1.33	.99843	639	36.47	.98172	0.67	0.67
	1388	4231	5	620	3.67	2	1.67	.99882	846	124.00	.99409	0.73	0.83
	1412	3847	7	620	5.17	3	2.50	.99818	550	88.57	.99167	0.74	0.83
CENTRAL EAST	1402	6217	8	620	5.67	4	3.00	.99871	777	77.50	.99086	0.71	0.75
	1393	2429	5	620	3.33	1	0.67	.99794	486	124.00	.99462	0.67	0.67
	1417	4053	5	620	3.33	2	1.33	.99877	811	124.00	.99462	0.67	0.67
	1418	7391	5	620	3.67	1	1.00	.99932	1478	124.00	.99409	0.73	1.00
	1423	416	0	620	0.00	0	0.00	1	NA	NA	1	NA	NA
CHURCHILL SOUTH	1405	2209	1	620	0.67	1	0.67	.99955	2209	620.00	.99892	0.67	0.67
	1385	3685	6	620	4.00	1	0.67	.99837	614	103.33	.99355	0.67	0.67
	1410	6501	2	620	1.33	0	0.00	.99969	3250	310.00	.99785	0.67	NA
	1424	820	2	620	1.33	0	0.00	.99756	410	310.00	.99785	0.67	NA
CHURCHILL NORTH	1403	1988	2	620	1.33	0	0.00	.99899	994	310.00	.99785	0.67	NA
	1419	4198	1	620	0.67	0	0.00	.99976	4198	620.00	.99892	0.67	NA
	1384	8014	9	620	6.33	1	1.00	.99888	890	68.89	.98978	0.70	1.00
STADIUM	1395	6185	7	620	4.83	1	0.83	.99887	884	88.57	.99220	0.69	0.83
	1381	4930	4	620	2.67	1	0.67	.99919	1232	155.00	.99570	0.67	0.67
	1396	3788	3	620	2.00	0	0.00	.99921	1263	206.67	.99677	0.67	NA
	1407	3499	5	620	4.00	3	2.67	.99857	700	124.00	.99355	0.80	0.89
	1386	2297	5	620	3.33	0	0.00	.99782	459	124.00	.99462	0.67	NA
	1390	3321	5	620	3.33	1	0.67	.99849	664	124.00	.99462	0.67	0.67
	1425	273	2	620	1.33	1	0.67	.99267	136	310.00	.99785	0.67	0.67
	1422	810	2	620	1.33	1	0.67	.99753	405	310.00	.99785	0.67	0.67
COLISEUM NORTH	1382	2677	5	620	3.33	1	0.67	.99813	535	124.00	.99462	0.67	0.67
	1387	1447	3	620	3.00	3	3.00	.99793	482	206.67	.99516	1.00	1.00
	1394	1130	8	620	5.67	3	2.33	.99292	141	77.50	.99086	0.71	0.78
	1401	1905	9	620	6.83	4	3.50	.99528	212	68.89	.98898	0.76	0.88
	1400	2415	8	620	6.17	4	3.50	.99669	302	77.50	.99005	0.77	0.88
	1391	5531	9	620	6.67	2	2.00	.99837	615	68.89	.98925	0.74	1.00
	1422	810	2	620	1.33	1	0.67	.99753	405	310.00	.99785	0.67	0.67
	1422	810	2	620	1.33	1	0.67	.99753	405	310.00	.99785	0.67	0.67
COLISEUM SOUTH	1415	574	0	620	0.00	0	0.00	1	NA	NA	1	NA	NA
	1413	569	2	620	1.33	0	0.00	.99649	284	310.00	.99785	0.67	NA
BELVEDERE	1404	13220	12	620	8.00	1	0.67	.99909	1102	51.67	.98710	0.67	0.67
	1409	10966	13	620	9.00	4	3.00	.99881	844	47.69	.98548	0.69	0.75
	1421	3660	13	620	9.33	3	2.67	.99645	282	47.69	.98495	0.72	0.89
CLAREVIEW	1406	1612	3	620	2.50	2	1.83	.99814	537	206.67	.99597	0.83	0.92
	1389	3019	10	620	6.83	2	1.50	.99669	302	62.00	.98898	0.68	0.75
	1397	6161	4	620	2.67	0	0.00	.99935	1545	155.00	.99570	0.67	NA
	1392	5816	14	620	10.33	4	3.67	.99759	415	44.29	.98333	0.74	0.92
	1420	137	7	620	5.83	6	5.17	.94891	20	88.57	.99059	0.83	0.86
SUMMARY													
CENTRAL		51446	71	5580	49.17	17	13.17	.99862	725	78.59	.99119	0.69	0.77
CHURCHILL		27415	23	4340	15.67	3	2.33	.99916	1192	188.70	.99639	0.68	0.78
STADIUM		24293	31	4340	21.50	7	5.50	.99872	784	140.00	.99505	0.69	0.79
COLISEUM		17058	46	5580	34.33	18	15.67	.99730	371	121.30	.99385	0.75	0.87
BELVEDERE		27846	38	1860	26.33	8	6.33	.99864	733	48.95	.98584	0.69	0.79
CLAREVIEW		16765	38	3100	28.17	14	12.17	.99773	441	81.58	.99091	0.74	0.87
SYSTEM		164823	247	24800	175.17	67	55.17	.99850	667	100.40	.99294	0.71	0.82

TABLE 4-9  
SEPTEMBER PERFORMANCE - EDMONTON

SEP 82		TRANS	FAILS	OP TIME (HRS)	DOWN TIME (HRS)	HARD FAIL	HARD DOWN TIME (HRS)	R	MTF	MTBF (HRS)	A	ADT (HRS)	MTTR (HRS)
CENTRAL WEST	1383	10948	22	600	14.83	4	2.83	.99799	498	27.27	.97528	0.67	0.71
	1398	9246	20	600	13.67	2	1.67	.99784	462	30.00	.97722	0.68	0.83
	1388	2931	6	600	4.00	1	0.67	.99795	488	100.00	.99333	0.67	0.67
	1412	3264	8	600	5.33	1	0.67	.99755	408	75.00	.99111	0.67	0.67
CENTRAL EAST	1402	5247	10	600	7.33	5	4.00	.99809	525	60.00	.98778	0.73	0.80
	1393	1535	5	600	3.33	1	0.67	.99674	307	120.00	.99444	0.67	0.67
	1417	3852	5	600	3.33	2	1.33	.99870	770	120.00	.99444	0.67	0.67
	1418	6106	11	600	8.83	6	5.50	.99820	555	54.55	.98528	0.80	0.92
	1423	317	0	600	0.00	0	0.00	1	NA	NA	1	NA	NA
CHURCHILL SOUTH	1405	1939	8	600	6.17	3	2.83	.99587	242	75.00	.98972	0.77	0.94
	1385	2986	9	600	6.00	1	0.67	.99699	332	66.67	.99	0.67	0.67
	1410	5797	7	600	4.67	0	0.00	.99879	828	85.71	.99222	0.67	NA
	1424	751	1	600	0.67	0	0.00	.99867	751	600.00	.99889	0.67	NA
CHURCHILL NORTH	1403	1805	0	600	0.00	0	0.00	1	NA	NA	1	NA	NA
	1419	2686	2	600	1.33	1	0.67	.99926	1343	300.00	.99778	0.67	0.67
	1384	7939	5	600	3.33	0	0.00	.99937	1588	120.00	.99444	0.67	NA
STADIUM	1395	5140	13	600	9.00	2	1.67	.99747	395	46.15	.985	0.69	0.83
	1381	3791	4	600	2.67	1	0.67	.99894	948	150.00	.99556	0.67	0.67
	1396	2755	6	600	4.17	3	2.17	.99782	459	100.00	.99306	0.69	0.72
	1407	2476	9	600	6.33	3	2.33	.99637	275	66.67	.98944	0.70	0.78
	1386	1548	5	600	4.00	2	2.00	.99677	310	120.00	.99333	0.80	1.00
	1390	2803	10	600	7.00	4	3.00	.99643	280	60.00	.98833	0.70	0.75
	1425	254	2	600	1.33	1	0.67	.99213	127	300.00	.99778	0.67	0.67
COLISEUM NORTH	1382	3640	4	600	2.67	1	0.67	.99890	910	150.00	.99556	0.67	0.67
	1387	2013	1	600	1.00	1	1.00	.99950	2013	600.00	.99833	1.00	1.00
	1394	1724	6	600	4.00	1	0.67	.99652	287	100.00	.99333	0.67	0.67
	1401	2658	9	600	6.50	2	1.83	.99661	295	66.67	.98917	0.72	0.92
	1400	2589	10	600	7.33	3	2.67	.99614	259	60.00	.98778	0.73	0.89
	1391	5759	7	600	4.67	0	0.00	.99878	823	85.71	.99222	0.67	NA
	1422	812	4	600	3.00	1	1.00	.99507	203	150.00	.995	0.75	1.00
COLISEUM SOUTH	1415	673	2	600	1.33	0	0.00	.99703	336	300.00	.99778	0.67	NA
	1413	568	1	600	0.67	1	0.67	.99824	568	600.00	.99889	0.67	0.67
BELVEDERE	1404	10850	8	600	5.67	3	2.33	.99926	1356	75.00	.99056	0.71	0.78
	1409	10439	9	600	6.33	2	1.67	.99914	1160	66.67	.98944	0.70	0.83
	1421	2611	13	600	8.67	0	0.00	.99502	201	46.15	.98556	0.67	NA
CLAREVIEW	1406	1121	7	600	4.67	0	0.00	.99376	160	85.71	.99222	0.67	NA
	1389	2363	7	600	4.67	1	0.67	.99704	338	85.71	.99222	0.67	0.67
	1397	4114	14	600	9.67	2	1.67	.99660	294	42.86	.98389	0.69	0.83
	1392	6067	10	600	6.67	2	1.33	.99835	607	60.00	.98889	0.67	0.67
	1420	109	7	600	4.67	0	0.00	.93578	16	85.71	.99222	0.67	NA
SUMMARY													
CENTRAL		43446	87	5400	60.67	22	17.33	.99800	499	62.07	.98877	0.70	0.79
CHURCHILL		23903	32	4200	22.17	5	4.17	.99866	747	131.25	.99472	0.69	0.83
STADIUM		18767	49	4200	34.50	16	12.50	.99739	383	85.71	.99179	0.70	0.78
COLISEUM		20436	44	5400	31.17	10	8.50	.99785	464	122.73	.99423	0.71	0.85
BELVEDERE		23900	30	1800	20.67	5	4.00	.99874	797	60.00	.98852	0.69	0.80
CLAREVIEW		13774	45	3000	30.33	5	3.67	.99673	306	66.67	.98989	0.67	0.73
SYSTEM		144226	287	24000	199.50	63	50.17	.99801	503	83.62	.99169	0.70	0.80

TABLE 4-10  
JULY TO SEPTEMBER PERFORMANCE - EDMONTON

		TRANS	FAILS	OP TIME (HRS)	DOWN TIME (HRS)	HARD FAIL	HARD DOWN TIME (HRS)	R	MTF	MTBF (HRS)	A	ADT (HRS)	MTTR (HRS)
CENTRAL WEST	1383	156408	70	1840	47.17	8	5.83	.99955	2234	26.29	.97437	0.67	0.73
	1398	153109	63	1840	42.50	7	5.17	.99959	2430	29.21	.97690	0.67	0.74
	1388	56632	17	1840	11.67	4	3.00	.99970	3331	108.24	.99366	0.69	0.75
	1412	64269	26	1840	17.83	4	3.17	.99960	2472	70.77	.99031	0.69	0.79
CENTRAL EAST	1402	107309	38	1840	26.50	11	8.50	.99965	2824	48.42	.98560	0.70	0.77
	1399	42029	19	1840	12.67	5	3.33	.99955	2212	96.84	.99312	0.67	0.67
	1417	64690	14	1840	9.33	5	3.33	.99978	4621	131.43	.99493	0.67	0.67
	1418	123456	27	1840	19.83	7	6.50	.99978	4572	68.15	.98922	0.73	0.93
	1423	6731	4	1840	3.00	2	1.67	.99941	1683	460.00	.99837	0.75	0.83
CHURCHILL SOUTH	1405	40843	13	1840	9.67	5	4.33	.99968	3142	141.54	.99475	0.74	0.87
	1395	64130	25	1840	17.00	4	3.00	.99961	2565	73.60	.99076	0.68	0.75
	1410	112087	18	1840	12.50	3	2.50	.99984	6227	102.22	.99321	0.69	0.83
	1424	229692	7	1840	4.83	1	0.83	.99997	32813	262.86	.99737	0.69	0.83
CHURCHILL NORTH	1403	35515	5	1840	3.83	2	1.83	.99986	7103	368.00	.99792	0.77	0.92
	1419	56858	5	1840	3.33	1	0.67	.99991	11372	368.00	.99819	0.67	0.67
	1384	130930	30	1840	20.67	2	2.00	.99977	4364	61.33	.98877	0.69	1.00
STADIUM	1395	87757	29	1840	19.83	4	3.17	.99967	3026	63.45	.98922	0.68	0.79
	1381	65038	14	1840	9.33	5	3.33	.99978	4646	131.43	.99493	0.67	0.67
	1396	46923	14	1840	9.67	4	3.00	.99970	3352	131.43	.99475	0.69	0.75
	1407	45954	17	1840	12.67	7	6.00	.99963	2703	108.24	.99312	0.75	0.86
	1386	26604	19	1840	13.33	3	2.67	.99929	1400	96.84	.99275	0.70	0.89
	1390	54508	21	1840	14.67	6	4.67	.99961	2596	87.62	.99203	0.70	0.78
	1425	4796	8	1840	5.67	4	3.00	.99833	599	230.00	.99692	0.71	0.75
COLISEUM NORTH	1382	75585	20	1840	13.33	5	3.33	.99974	3779	92.00	.99275	0.67	0.67
	1387	57408	14	1840	10.67	5	4.67	.99976	4101	131.43	.99420	0.76	0.93
	1394	61605	19	1840	13.17	6	4.50	.99969	3242	96.84	.99284	0.69	0.75
	1401	79575	27	1840	19.67	8	7.00	.99966	2947	68.15	.98931	0.73	0.88
	1400	67652	28	1840	20.17	9	7.50	.99959	2416	65.71	.98904	0.72	0.83
	1391	139348	39	1840	26.83	5	4.17	.99972	3573	47.18	.98542	0.69	0.83
	1422	25660	7	1840	5.00	3	2.33	.99973	3666	262.86	.99728	0.71	0.78
COLISEUM SOUTH	1415	2602	5	1840	3.33	0	0.00	.99808	520	368.00	.99819	0.67	NA
	1413	13816	6	1840	4.00	2	1.33	.99957	2303	306.67	.99783	0.67	0.67
BELVEDERE	1404	192486	38	1840	26.33	6	5.00	.99980	5065	48.42	.98569	0.69	0.83
	1409	165508	38	1840	26.00	7	5.33	.99977	4355	48.42	.98587	0.68	0.76
	1421	57808	39	1840	27.33	5	4.67	.99933	1482	47.18	.98514	0.70	0.93
CLAREVIEW	1406	26161	26	1840	18.17	5	4.17	.99901	1006	70.77	.99013	0.70	0.83
	1389	45239	25	1840	16.83	5	3.50	.99945	1810	73.60	.99085	0.67	0.70
	1397	80777	36	1840	24.50	4	3.17	.99955	2244	51.11	.98668	0.68	0.79
	1392	101986	39	1840	27.00	6	5.00	.99962	2615	47.18	.98533	0.69	0.83
	1420	4538	16	1840	11.83	6	5.17	.99647	284	115.00	.99357	0.74	0.86
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SUMMARY													
CENTRAL		774633	278	16560	190.50	53	40.50	.99964	2786	59.57	.98850	0.69	0.76
CHURCHILL		670055	103	12880	71.83	18	15.17	.99985	6505	125.05	.99442	0.70	0.84
STADIUM		331580	122	12880	85.17	33	25.83	.99963	2718	105.57	.99339	0.70	0.78
COLISEUM		523251	165	16560	116.17	43	34.83	.99968	3171	100.36	.99299	0.70	0.81
BELVEDERE		415802	115	5520	79.67	18	15.00	.99972	3616	48.00	.98557	0.69	0.83
CLAREVIEW		258701	142	9200	98.33	26	21.00	.99945	1822	64.79	.98931	0.69	0.81
SYSTEM		2974022	925	73600	641.67	191	152.33	.99969	3215	79.57	.99128	0.69	0.80

TABLE 4-11  
SUMMARY OF COMPONENT PERFORMANCE - EDMONTON

COMPONENT	TRANS	OP TIME (HRS)	TOTAL		TOTAL DOWN TIME (HRS)	TOTAL HARD FAILS	R	MTF	MTBF (HRS)	A	ADT (HRS)	MTTR (HRS)
			DOWN TIME (HRS)	HARD FAILS								
ELECTRONIC CH.	2974022	73600	19	16.00	10	10	.999994	156526	3873.68	.999783	0.84	1.00
COIN MECH.	2974022	73600	287	197.33	65	49	.999903	10362	256.45	.997319	0.69	0.76
TICKET DISP.	2974022	73600	513	345.33	10	10	.999828	5797	143.47	.995308	0.67	1.00
CASH STORAGE	2974022	73600	15	10	15	10	.999995	198267	4906.67	.999864	0.67	0.67
ELECTRIC SYS.	2974022	73600	61	43.00	61	43	.999979	48754	1206.56	.999416	0.70	0.70
MISC.	2974022	73600	30	30.00	30	30	.999990	99134	2453.33	.999592	1.00	1.00
SYSTEM	2974022	73600	925	641.66	191	152	.999689	3215	79.57	.991282	0.69	0.80

period. More detailed tabulations for each component by station are presented in Appendix B. As in the case of Calgary, station and system availability in Tables 4-3 to 4-11 are the average values computed according to the PEP definition. Table 4-12 compares these averages to the other measures of MTBF and availability defined in Section 2. The probability of at least one machine being available at any station is very close to unity and, therefore, is not shown in Table 4-12.

#### 4.3.2 Data Interpretation

Like Calgary, Edmonton also achieves a very high station availability. The prospect that a passenger can legitimately claim he or she was unable to obtain a proof-of-payment because all machines were down at a particular station is virtually zero. Average availabilities are similar to those experienced in Calgary although full availabilities are marginally lower. The measure of overall system MTBF for Edmonton of 1.99 hours compared to 4.34 hours for Calgary indicates approximately double the incidence of service calls at Edmonton. MTTR values at Edmonton and Calgary were 0.8 and 0.92 hours, respectively, indicating somewhat less complicated repairs at Edmonton, as expected because of the higher incidence of coin acceptor jams.

The main observations made after studying the performance measures over the survey periods are that 1) reliability improves with a greater number of transactions while availability and maintainability become somewhat worse, and 2) the ticket dispenser and coin mechanism are the least reliable components.

The observation that reliability (R and MTF) improves with an increase in transactions was surprising, and at first the validity of the raw data was questioned. Dave Pagett of Edmonton vouched for the data, and indicated that he was aware of the phenomenon and was wondering if the present analysis would show the same results. A comparison of July with either August or September shows that while transactions are around 16 times greater in July, the failures are only around 1.5 times greater. A comparison of individual machines within a single month shows, in general, that more transactions yield higher reliability. The six machines without turnstiles (1420-1425) have the smallest number of transactions at all stations because they are out of the main passenger flow, and have some of the worst MTFs.

There are three speculative explanations for this paradox. First, coin mechanism jams are mainly caused by people depositing small pieces of paper in the coin slot either in an attempt to fool the coin tester, or simply to jam the machines

TABLE 4-12  
EDMONTON STATION RELIABILITY AND AVAILABILITY

STATION	MACHINE STATION		FAILS	DOWN TIME (HRS)	MTBF1 (HRS)	MTBF2 (HRS)	A1	A2
	OP TIME (HRS)	OP TIME (HRS)						
CENTRAL	16560	1840	278	190.50	59.57	6.62	.988496	.896467
CHURCHILL	12880	1840	103	71.83	125.05	17.86	.994423	.960762
STADIUM	12880	1840	122	85.17	105.57	15.08	.993388	.953714
COLISEUM	16560	1840	165	116.17	100.36	11.15	.992985	.936866
BELVEDERE	5520	1840	115	79.67	48.00	16.00	.985568	.956703
CLAREVIEW	9200	1840	142	98.33	64.79	12.96	.989312	.946558
SYSTEM	73600	1840	825	641.67	79.57	1.99	.991282	.651268

MTBF1 -- AVERAGE OF THE MTBF'S OF THE MACHINES AT EACH STATION (OR FOR THE SYSTEM)

MTBF2 -- MTBF AT A STATION (OR FOR THE SYSTEM)

A1 -- AVERAGE OF THE AVAILABILITIES OF THE MACHINES AT EACH STATION (OR FOR THE SYSTEM)

A2 -- PROBABILITY THAT ALL MACHINES AT A STATION (OR THE SYSTEM) ARE AVAILABLE



so they can claim that they were not able to purchase a ticket. The large number of tourists who swell the ranks of passengers by 16-fold in July probably discourage the paper stuffers since the machines are under more constant observation. Second, the greater volume of coins cause the coin mechanism to wear. They will also keep lint moving, and keep body oils and dirt from congealing, at least during the day. Third, similar comments apply to the ticket dispenser in that once the transport mechanism is moving tickets and the printer is printing, the machine oils that lubricate these devices probably do a better job. Further, the ticket stock itself may be in better condition since the time spent in the loop between the stock and the printer is less. Consider for a moment tickets sitting in this loop over night absorbing night moisture. The foregoing is of course pure speculation but in the future may help to determine the best time of day to observe the machines for failures and what to look for.

As might be expected availability (A) and maintainability (ADT and MTTR) measures decrease with the increase in transactions. The decrease, however, is not great, because all three of these measures depend upon failure count and down time. Total failures did not increase proportionately with transactions. Down time, because of the way it was estimated with a large fixed response time, does not vary greatly between failure categories.

The performance measures for individual components in Table 4-11 show that the coin mechanism and ticket dispenser have significantly lower MTFs than the other four components. The highest reliability was shown by the cash storage component (escrow unit and vault) as might be expected. The electronic chassis also shows relatively good reliability, which is typical of electronic systems after some period of attrition.

The measures for availability and maintainability must be considered with some skepticism because they were estimated some time after the survey periods. They nevertheless were computed and presented to show the method used when actual down time data might be recorded. Tables 4-13 and 4-14 tabulate the 95 percent confidence intervals for R and MTF for each station and the system for two survey periods--September and the combined July to September period. As expected, the July to September period with its greater number of transactions shows a much narrower variation in the range of R and MTF than does September alone. In either case the range is sufficiently narrow so that the computations for R and MTF can be used confidently to make comparisons.

TABLE 4-13  
 SEPTEMBER RELIABILITY 95% CONFIDENCE INTERVALS - EDMONTON

CONF INTVL		SEP 82							
STATION	TRANS	FAILS	LOW R	R	HIGH R	LOW MTF	MTF	HIGH MTF	
CENTRAL	43446	87	.997577	.997998	.998418	413	499	632	
CHURCHILL	23903	32	.998198	.998661	.999125	555	747	1143	
STADIUM	18767	49	.996659	.997389	.998119	299	383	532	
COLISEUM	20436	44	.997211	.997847	.998482	359	464	659	
BELVEDERE	23900	30	.998296	.998745	.999194	587	797	1240	
CLAREVIEW	13774	45	.995780	.996733	.997686	237	306	432	
SYSTEM	144226	287	.997780	.998010	.998240	450	503	568	

TABLE 4-14  
 JULY TO SEPTEMBER RELIABILITY 95% CONFIDENCE INTERVALS - EDMONTON

JUL-SEP		1982							
STATION	TRANS	FAILS	LOW R	R	HIGH R	LOW MTF	MTF	HIGH MTF	
CENTRAL	774633	278	.999599	.999641	.999683	2493	2786	3158	
CHURCHILL	670055	103	.999817	.999846	.999876	5452	6505	8062	
STADIUM	331580	122	.999567	.999632	.999697	2308	2718	3304	
COLISEUM	523251	165	.999637	.999685	.999733	2751	3171	3742	
BELVEDERE	415802	115	.999673	.999723	.999774	3057	3616	4424	
CLAREVIEW	258701	142	.999361	.999451	.999541	1565	1822	2180	
SYSTEM	2974022	925	.999669	.999689	.999709	3021	3215	3437	

## 5. CONCLUSIONS AND RECOMMENDATIONS

The Calgary and the Edmonton machines are compared in Section 5.1 with equipment of similar design and similar functions. The assessment did not indicate any significant difference between the self-service equipment used at these Canadian systems and the more traditional fare collection equipment. The assessment did indicate the need for additional work in several key areas. These are discussed in Section 5.2.

### 5.1 Comparison With Other Equipment

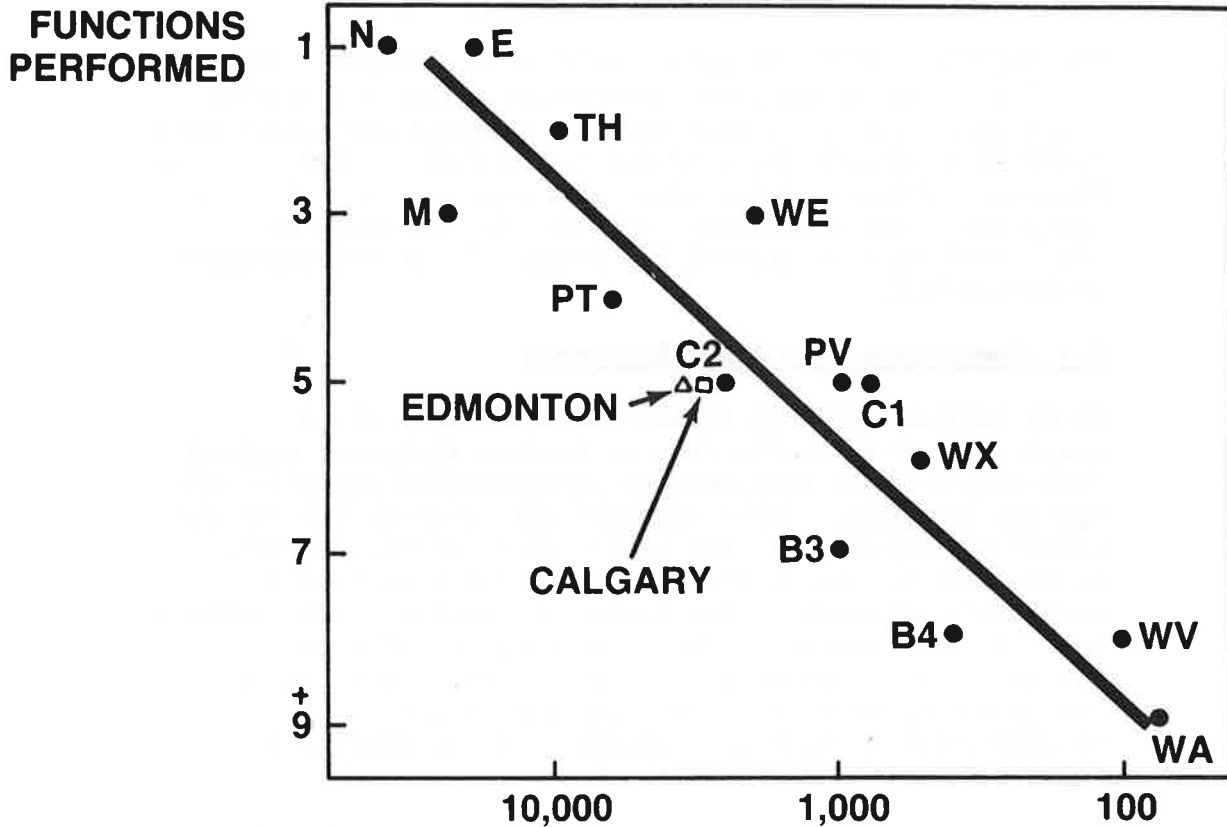
In an earlier study by Deibel and Wood (Ref. 2), a comparison of automatic fare collection equipment ranging from simple token equipment to sophisticated magnetic card systems was made. Their approach was to group the various pieces of equipment by the number of functions performed rather than by the sophistication of the electronics, mechanics, or media. They found, in general, that machines with the same number of functions also had similar reliabilities. Applying the same criteria, the ticket machines used by both Calgary and Edmonton have reliabilities similar to equipment with an equivalent number of functions.

The Calgary and Edmonton ticket machines are considered to be five-function devices:

<u>Calgary Ticket Machine Functions</u>	<u>Edmonton Ticket Machine Functions</u>
Single Coin Acceptance	Single Coin Acceptance
Additional Coin Acceptance	Additional Coin Acceptance
Print Ticket	Print Ticket
--	Transport ticket
Dispense Ticket	Dispense Ticket
Validate Ticket	--

The criteria for distinguishing between functions is that each function represents a separate failure mode. For example, a single coin or token acceptor can fail to sense a coin whereas a multiple coin unit can both fail to sense coins and fail to correctly identify a coin's denomination.

Figure 7 shows the relationship of the Calgary MTF (system average) of 2,522 and the Edmonton MTF (system average) of 3215 to equipment used by other transit systems. Both are located slightly on the favorable side of the trend line, and quite close to the Chicago Transit Authority (CTA) Type 2 Turnstile machines. The similarity between the Edmonton



### Reliability—Mean Transactions Per Failure

Legend:

- N--New York City Transit Authority (NCYTA) Token-Accepting Turnstile
- E--European Cancelling Machines
- TH--Port Authority Trans Hudson (PATH) Turnstile
- M--Montreal Turnstile
- WE--Washington (D.C.) Metro Entry Gate
- PT--Port Authority Transit Corporation (PATCO) Gate
- C2--Chicago Transit Authority (CTA) Type 2 Turnstile
- PV--PATCO Ticket Vending Machine
- C1--CTA Type 1 Turnstile
- WX--Washington (D.C.) Exit Gate
- B3--Bay Area Rapid Transit (BART) Type 3
- B4--BART Type 4 Gate
- WV--Washington Metro Ticket Vending Machine
- WA--Washington Metro Addfare Machine

FIGURE 7  
COMPARISON TO OTHER AFC EQUIPMENT

equipment and the CTA Type 2 Turnstile is not surprising since both have similar designs and are supplied by the same manufacturer, Duncan Industries.

## 5.2 Recommendations for Subsequent Evaluation

The Property Evaluation Plan (PEP) greatly facilitate the planning and execution of this assessment of the two transit systems as it provides the overall structure and definition of the assessment. Nonetheless, it was fairly difficult to accurately extract and to knowledgeably categorize the data from the maintained records because they were not organized according to the PEP procedures, which were unknown to them at the time. A short handbook describing both the PEP procedures and methods of recording the needed data would be useful. The recording method should let the maintenance personnel categorize the failure on-site, so that subsequent processing and analysis can proceed without further interpretation or second-guessing. Machine readable original records would be ideal, but even pre-printed checkoff sheets that could easily be entered into a data processing system without interpretation would be very helpful.

Most important is the apparent need to examine one of the basic assumptions of the PEP--that failures are normally distributed. The data from both Calgary and Edmonton suggest that failures do not increase as rapidly as transactions, i.e., that the assumption of a normal distribution may not be valid in all cases. The phenomena exhibited in this assessment should be studied more closely to determine if it indeed exists, and if so, what impact it has on the PEP.

The availability statistics defined by the PEP also do not provide sufficient information when used as measures of station and system performance in self-service operations. The average are satisfactory indicators of overall performance and are excellent for comparison purposes, but additional measures of availability are necessary to assess performance at the extremes, i.e., the probability of all equipment being operational and the probability that at least one machine is operational. While averages judge general satisfactory operation, the extremes for a self-service operation are important measures of the likelihood of compliance with self-service rules for proof-of-payment. High availability of all machines at a station is necessary to minimize passenger frustration that ultimately might lead to a rationalization for fare evasion. High availability of at least one machine at a station is imperative if the basis for the

entire enforcement program is to be upheld. These two availability measures should be part of all future assessments of self-service operations. Neither availability measure is as critical for a conventional barrier fare collection system but both do provide useful information and, if only on the basis of uniformity, both should be included as part of any future assessment and should be incorporated into the PEP.

Finally, additional data compatibility should be sought by developing and promoting the type of commercially-available software package used in this assessment. The reduction analysis and presentation of the data was greatly aided by the use of the VisiCalc(TM) Software Package. This package or one of its competitors is available for most personal and small business computers and allows a non-programmer to manipulate data and make many trial computations during analysis. A logical extension of this software, and one that would have aided greatly in the preparation of this report, would be a package that could sort the spread sheets by any user supplied field. This ability would have allowed a closer look at the ranking of the various computed measures. It would have, for example, facilitated the investigation of improved reliability at higher transaction levels by allowing a sort on the basis of transaction volume.

## 6. REFERENCES

1. Stevens, Richard F., "Automatic Fare Collection Property Evaluation Plan," Input Output Computer Services, Inc., prepared for the Transportation Systems Center, September, 1980.
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APPENDIX A  
CALGARY DETAILED PERFORMANCE STATISTICS



**TABLE A-1  
ELECTRONIC CHASSIS PERFORMANCE - CALGARY**

LOCATION	MACHINE	TRANS	OP TIME (HRS)	TOTAL FAILS	TOTAL DOWN TIME	TOTAL HARD FAILS	TOTAL DOWN TIME HARD	R	MTF	MTBF (HRS)	A	ADT (HRS)	MTTR (HRS)
ANDERSON	1	74772	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	2	46240	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	3	40341	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	4	24363	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
SOUTHLAND	5	35004	2180	1	1.56	0	0.00	.999971	35004	2180.00	.999283	1.56	NA
	7	34104	2180	1	1.56	0	0.00	.999971	34104	2180.00	.999283	1.56	NA
	6	27937	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
HERITAGE	8	35384	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	9	43054	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	10	21524	2180	1	1.56	0	0.00	.999954	21524	2180.00	.999283	1.56	NA
CHINOOK	11	50623	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	12	57221	2180	1	1.25	1	1.25	.999983	57221	2180.00	.999427	1.25	1.25
	34	31709	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
42ND AVE	14	38012	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	13	11060	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
ERLTON	15	10999	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	16	12905	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	17	11896	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
STAMPEDE	21	24482	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	18	31823	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	19	47695	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	20	34676	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
CITY HALL	22	11748	2180	1	1.56	0	0.00	.999915	11748	2180.00	.999283	1.56	NA
	23	9460	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	24	10310	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	25	27520	2180	1	1.25	1	1.25	.999964	27520	2180.00	.999427	1.25	1.25
CENTER	27	54705	2180	2	2.81	1	1.25	.999963	27352	1090.00	.998710	1.41	1.25
	28	41974	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	27	22355	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	26	42531	2180	1	1.56	0	0.00	.999976	42531	2180.00	.999283	1.56	NA
3RD ST W	30	39432	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	31	38939	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	32	22336	2180	1	1.56	0	0.00	.999955	22336	2180.00	.999283	1.56	NA
	33	44126	2180	1	1.56	0	0.00	.999977	44126	2180.00	.999283	1.56	NA
6TH ST W	35	29979	2180	1	1.56	0	0.00	.999967	29979	2180.00	.999283	1.56	NA
	36	3638	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	37	12306	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	38	24367	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
8TH ST W	39	44406	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	40	17238	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	41	10058	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA

**SUMMARY**

ANDERSON	185722	8720	0	0.00	0	0.00	1	NA	NA	1	NA	NA
SOUTHLAND	97045	6540	2	3.13	0	0.00	.999979	48522	3270.00	.999522	1.56	NA
HERITAGE	99962	6540	1	1.56	0	0.00	.999990	99961	6540.00	.999761	1.56	NA
CHINOOK	139553	6540	1	1.25	1	1.25	.999993	139552	6540.00	.999509	1.25	1.25
42ND AVE	49072	4360	0	0.00	0	0.00	1	NA	NA	1	NA	NA
ERLTON	43800	6540	0	0.00	0	0.00	1	NA	NA	1	NA	NA
STAMPEDE	138676	8720	0	0.00	0	0.00	1	NA	NA	1	NA	NA
CITY HALL	59038	8720	2	2.81	1	1.25	.999966	29519	4360.00	.999077	1.41	1.25
CENTER ST	161565	8720	3	4.30	1	1.25	.999981	53855	2906.67	.999498	1.48	1.25
3RD ST W	144835	8720	2	3.13	0	0.00	.999986	72417	4360.00	.999642	1.56	NA
6TH ST W	75290	8720	1	1.56	0	0.00	.999983	75290	8720.00	.999821	1.56	NA
8TH ST W	71702	6540	0	0.00	0	0.00	1	NA	NA	1	NA	NA
SYSTEM	1266260	89380	12	17.81	3	3.75	.999991	105521	7448.33	.999801	1.48	1.25

TABLE A-2  
COIN ACCEPTOR PERFORMANCE - CALGARY

LOCATION	MACHINE	TRANS	OF TIME (HRS)	TOTAL FAILS	TOTAL DOWN TIME	TOTAL HARD FAILS	TOTAL DOWN TIME HARD	R	MTF	MTBF (HRS)	A	ADT (HRS)	MTTR (HRS)
ANDERSON	1	74778	2180	5	3.33	0	0.00	.999933	14956	436.00	.998471	0.67	NA
	2	46240	2180	6	4.00	0	0.00	.999870	7707	363.33	.998165	0.67	NA
	3	40341	2180	1	0.67	0	0.00	.999975	40341	2180.00	.999694	0.67	NA
	4	24363	2180	2	1.33	0	0.00	.999918	12181	1090.00	.999388	0.67	NA
SOUTHLAND	5	35004	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	7	34104	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	6	27937	2180	2	1.33	0	0.00	.999928	13968	1090.00	.999388	0.67	NA
HERITAGE	8	35384	2180	1	0.67	0	0.00	.999972	35384	2180.00	.999694	0.67	NA
	9	43054	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	10	21524	2180	2	1.33	0	0.00	.999907	10762	1090.00	.999388	0.67	NA
CHINOOK	11	50623	2180	3	1.33	1	0.75	.999941	16874	726.67	.999388	0.44	0.75
	12	57221	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	34	31709	2180	1	0.67	0	0.00	.999968	31709	2180.00	.999694	0.67	NA
42ND AVE	14	38012	2180	9	5.33	1	1.25	.999763	4224	242.22	.997554	0.59	1.25
	12	11060	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
ERLTON	15	18999	2180	5	3.33	0	0.00	.999737	3800	436.00	.998471	0.67	NA
	16	12905	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	17	11896	2180	1	0.67	1	1.25	.999916	11896	2180.00	1	0.67	1.25
STAMPEDE	21	24482	2180	3	2.00	0	0.00	.999877	8161	726.67	.999083	0.67	NA
	18	31823	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	19	47695	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	20	34676	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
CITY HALL	22	11748	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	23	9460	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	24	10310	2180	1	0.67	0	0.00	.999903	10310	2180.00	.999694	0.67	NA
	25	27520	2180	5	2.67	1	0.75	.999818	5504	436.00	.998777	0.53	0.75
CENTER	29	54705	2180	4	2.67	0	0.00	.999927	13676	545.00	.998777	0.67	NA
	28	41974	2180	4	2.00	1	0.75	.999905	10493	545.00	.999083	0.50	0.75
	27	22355	2180	1	0.67	0	0.00	.999955	22355	2180.00	.999694	0.67	NA
	26	42531	2180	1	0.67	0	0.00	.999976	42531	2180.00	.999694	0.67	NA
3RD ST W	30	39432	2180	4	2.00	1	0.75	.999899	9858	545.00	.997803	0.50	0.75
	31	38939	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	32	22338	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	33	44126	2180	7	4.67	0	0.00	.999841	6304	311.43	.997803	0.67	NA
6TH ST W	35	29979	2180	1	0.67	0	0.00	.999967	29979	2180.00	.999694	0.67	NA
	36	3638	2180	3	2.00	0	0.00	.999653	2679	726.67	.999083	0.67	NA
	37	12306	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	38	24367	2180	1	0.67	0	0.00	.999959	24367	2180.00	.999694	0.67	NA
8TH ST W	39	44406	2180	2	1.33	0	0.00	.999955	22203	1090.00	.999388	0.67	NA
	40	17238	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	41	10056	2180	3	1.33	1	1.25	.999702	3353	726.67	.999388	0.44	1.25
SUMMARY													
ANDERSON		185722	8720	14	3.33	0	0.00	.999925	13266	622.06	.998930	0.67	NA
SOUTHLAND		97045	6540	2	1.33	0	0.00	.999979	48522	3270.00	.999796	0.67	NA
HERITAGE		99962	6540	3	2.00	0	0.00	.999970	33321	2180.00	.999694	0.67	NA
CHINOOK		139553	6540	4	2.00	1	0.75	.999971	34886	1635.00	.999694	0.50	0.75
42ND AVE		49072	4360	9	5.33	1	1.25	.999817	5452	484.44	.996777	0.59	1.25
ERLTON		43800	6540	6	3.33	1	1.25	.999863	7300	1090.00	.999490	0.56	1.25
STAMPEDE		138676	8720	3	2.00	0	0.00	.999978	46225	2906.67	.999771	0.67	NA
CITY HALL		59038	8720	6	3.33	1	0.75	.999898	9840	1453.33	.999616	0.56	0.75
CENTER ST		161565	8720	10	6.00	1	0.75	.999938	16156	372.00	.998312	0.50	0.75
3RD ST W		144835	8720	11	6.67	1	0.75	.999924	13167	792.73	.999235	0.61	0.75
6TH ST W		75290	8720	5	3.33	0	0.00	.999934	15058	1744.00	.999618	0.67	NA
8TH ST W		71702	6540	5	2.67	1	1.25	.999930	14340	1308.00	.999592	0.53	1.25
SYSTEM		1266260	89380	78	47.33	7	6.75	.999938	16204	1145.90	.999470	0.61	0.96

TABLE A-3  
TICKET DISPENSER PERFORMANCE - CALGARY

LOCATION MACHINE	TRANS	OP TIME (HRS)	TOTAL FAILS	TOTAL DOWN TIME	TOTAL HARD FAILS	TOTAL DOWN TIME HARD	R	MTF	MTBF (HRS)	A	ADT (HRS)	MTRR (HRS)
ANDERSON	1 74778	2180	9	6.08	1	0.75	.999880	8309	242.22	.997209	0.68	0.75
	2 46240	2180	6	4.50	1	1.17	.999870	7707	363.33	.997936	0.75	1.17
	3 40341	2180	4	3.17	1	1.17	.999901	10085	545.00	.998547	0.79	1.17
	4 24363	2180	5	4.50	2	2.50	.999795	4873	436.00	.997936	0.90	1.25
SOUTHLAND	5 35004	2180	3	2.00	0	0.00	.999914	11668	726.67	.999083	0.67	NA
	7 34104	2180	5	3.33	0	0.00	.999853	6821	436.00	.998471	0.67	NA
	6 27937	2180	5	3.33	0	0.00	.999821	5587	436.00	.998471	0.67	NA
HERITAGE	8 35384	2180	4	2.67	0	0.00	.999887	8846	545.00	.998777	0.67	NA
	9 43054	2180	9	6.25	3	2.25	.999791	4784	242.22	.997133	0.69	0.75
	10 21524	2180	4	2.67	0	0.00	.999814	5381	545.00	.998777	0.67	NA
CHINOOK	11 50623	2180	14	10.50	4	3.33	.999723	3616	155.71	.995183	0.75	0.96
	12 57221	2180	8	5.33	0	0.00	.999860	7153	272.50	.997554	0.67	NA
	34 31709	2180	11	7.83	6	4.50	.999653	2883	198.18	.996407	0.71	0.75
42ND AVE	14 38012	2180	7	5.25	2	1.92	.999816	5430	311.43	.997592	0.75	0.96
	13 11060	2180	13	10.50	10	8.50	.998825	851	167.69	.995183	0.81	0.85
ERLTON	15 18999	2180	3	2.08	1	0.75	.999842	6333	726.67	.999044	0.69	0.75
	16 12905	2180	2	1.42	1	0.75	.999845	6452	1090.00	.999350	0.71	0.75
	17 11896	2180	2	1.42	1	0.75	.999832	5948	1090.00	.999350	0.71	0.75
STAMPEDE	21 24482	2180	4	2.67	0	0.00	.999637	6120	545.00	.998777	0.67	NA
	18 31823	2180	5	3.33	0	0.00	.999843	6365	436.00	.998471	0.67	NA
	19 47695	2180	4	2.67	0	0.00	.999916	11924	545.00	.998777	0.67	NA
	20 34676	2180	5	3.33	0	0.00	.999856	6935	436.00	.998471	0.67	NA
CITY HALL	22 11748	2180	4	2.75	1	0.75	.999660	2937	545.00	.998739	0.69	0.75
	23 9460	2180	3	3.25	3	3.25	.999683	3153	726.67	.998509	1.08	1.08
	24 10310	2180	5	4.67	5	4.67	.999515	2062	436.00	.997859	0.93	0.93
	25 27520	2180	4	2.67	0	0.00	.999855	6880	545.00	.998777	0.67	NA
CENTER	29 54705	2180	6	4.58	2	1.92	.999890	9117	363.33	.997898	0.76	0.96
	28 41974	2180	11	9.00	5	5.00	.999738	3816	198.18	.995872	0.82	1.00
	27 22355	2180	7	5.50	4	3.50	.999687	3194	311.43	.997477	0.79	0.88
	26 42531	2180	15	11.25	9	7.25	.999647	2835	145.33	.994839	0.75	0.81
3RD ST W	30 39432	2180	7	5.83	2	2.50	.999822	5633	311.43	.997324	0.83	1.25
	31 36939	2180	4	2.67	0	0.00	.999897	9735	545.00	.998777	0.67	NA
	32 22338	2180	4	3.25	2	1.92	.999821	5584	545.00	.998509	0.81	0.96
	33 44126	2180	7	4.75	1	0.75	.999841	6304	311.43	.997821	0.68	0.75
6TH ST W	35 29979	2180	2	1.33	0	0.00	.999933	14989	1090.00	.999386	0.67	NA
	36 8638	2180	4	2.67	0	0.00	.999837	2159	545.00	.998777	0.67	NA
	37 12306	2180	8	5.83	6	4.50	.999350	1538	272.50	.997324	0.73	0.75
	38 24367	2180	6	4.75	3	2.75	.999754	4061	363.33	.997821	0.79	0.92
8TH ST W	39 44406	2180	7	5.33	3	2.67	.999842	6344	311.43	.997554	0.76	0.89
	40 17238	2180	7	6.42	5	5.08	.999594	2463	311.43	.997057	0.92	1.02
	41 10058	2180	4	3.33	2	2.00	.999602	2514	545.00	.998471	0.83	1.00
SUMMARY												
ANDERSON	185722	8720	24	18.25	5	5.58	.999871	7738	363.33	.997907	0.76	1.12
SOUTHLAND	97045	6540	13	8.67	0	0.00	.999866	7465	503.08	.998675	0.67	NA
HERITAGE	99962	6540	17	11.58	3	2.25	.999830	5880	384.71	.998229	0.68	0.75
CHINOOK	139553	6540	33	23.67	10	8.33	.999764	4229	198.18	.996381	0.72	0.83
42ND AVE	49072	4360	20	15.75	12	10.42	.999592	2454	218.00	.996388	0.79	0.87
ERLTON	43800	6540	7	4.92	3	2.25	.999840	6257	934.29	.999248	0.70	0.75
STAMPEDE	138674	8720	18	12.00	0	0.00	.999870	7704	484.44	.998624	0.67	NA
CITY HALL	59098	8720	16	13.33	9	8.67	.999729	3690	545.00	.998471	0.83	0.96
CENTER ST	161565	8720	39	30.33	20	17.67	.999759	4143	223.59	.996521	0.78	0.88
3RD ST W	144835	8720	22	16.50	5	5.17	.999848	6583	394.36	.998108	0.75	1.03
6TH ST W	75290	8720	20	14.58	9	7.25	.999734	3764	436.00	.998328	0.73	0.81
8TH ST W	71702	6540	18	15.08	10	9.75	.999749	3983	363.33	.997694	0.84	0.97
SYSTEM	1266260	39380	247	184.67	86	77.33	.999805	5127	361.86	.997934	0.75	0.90

TABLE A-4  
TICKET VALIDATOR PERFORMANCE - CALGARY

LOCATION	MACHINE	TRANS	OP TIME (HRS)	TOTAL FAILS	TOTAL DOWN TIME	TOTAL HARD FAILS	TOTAL DOWN TIME HARD	R	MTF	MTBF (HRS)	A	ADT (HRS)	MTTR (HRS)
ANDERSON	1	74778	2180	1	0.75	0	0.00	.999987	74778	2180.00	.999656	0.75	NA
	2	46240	2180	6	4.50	0	0.00	.999870	7707	363.33	.997936	0.75	NA
	3	40341	2180	1	0.75	0	0.00	.999975	40341	2180.00	.999656	0.75	NA
	4	24363	2180	3	2.17	0	0.00	.999877	5121	726.67	.999006	0.72	NA
SOUTHLAND	5	35004	2180	2	1.50	0	0.00	.999943	17502	1090.00	.999312	0.75	NA
	7	34104	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	6	27537	2180	1	0.75	0	0.00	.999964	27537	2180.00	.999656	0.75	NA
HERITAGE	8	35384	2180	3	2.25	0	0.00	.999915	11795	726.67	.998968	0.75	NA
	9	43054	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	10	21524	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
CHINOOK	11	50623	2180	1	0.75	0	0.00	.999980	50623	2180.00	.999656	0.75	NA
	12	57221	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	34	31709	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
42ND AVE	14	38012	2180	3	2.25	0	0.00	.999921	12671	726.67	.998968	0.75	NA
	13	11060	2180	4	2.92	0	0.00	.999638	2765	545.00	.998662	0.73	NA
ERLTON	15	18999	2180	1	0.67	0	0.00	.999947	18999	2180.00	.999694	0.67	NA
	16	12905	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	17	11896	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
STAMPEDE	21	24482	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	18	31823	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	19	47695	2180	1	0.75	0	0.00	.999979	47695	2180.00	.999656	0.75	NA
	20	34676	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
CITY HALL	22	11748	2180	4	2.75	0	0.00	.999660	2937	545.00	.998739	0.69	NA
	23	9460	2180	2	1.50	0	0.00	.999789	4730	1090.00	.999312	0.75	NA
	24	10310	2180	1	0.75	0	0.00	.999903	10310	2180.00	.999656	0.75	NA
	25	27520	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
CENTER	29	54705	2180	1	0.75	0	0.00	.999982	54705	2180.00	.999656	0.75	NA
	28	41974	2180	2	1.50	0	0.00	.999952	20987	1090.00	.999312	0.75	NA
	27	22355	2180	1	0.75	0	0.00	.999955	22355	2180.00	.999656	0.75	NA
	26	42531	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
3RD ST W	30	39432	2180	1	0.75	0	0.00	.999975	39432	2180.00	.999656	0.75	NA
	31	38939	2180	1	0.75	0	0.00	.999974	38939	2180.00	.999656	0.75	NA
	32	22338	2180	1	0.75	0	0.00	.999955	22338	2180.00	.999656	0.75	NA
	33	44126	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
6TH ST W	35	29979	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	36	8638	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	37	12306	2180	3	2.17	0	0.00	.999756	4102	726.67	.999006	0.72	NA
	38	24367	2180	1	0.75	0	0.00	.999959	24367	2180.00	.999656	0.75	NA
8TH ST W	39	44406	2180	2	1.42	0	0.00	.999955	22203	1090.00	.999350	0.71	NA
	40	17238	2180	2	1.50	0	0.00	.999884	8619	1090.00	.999312	0.75	NA
	41	10058	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
SUMMARY													
ANDERSON		185722	8720	11	8.17	0	0.00	.999941	16884	792.73	.999063	0.74	NA
SOUTHLAND		97045	6540	3	2.25	0	0.00	.999969	32346	2180.00	.999656	0.75	NA
HERITAGE		99962	6540	3	2.25	0	0.00	.999970	33321	2180.00	.999656	0.75	NA
CHINOOK		139553	6540	1	0.75	0	0.00	.999923	139552	6540.00	.999885	0.75	NA
42ND AVE		49072	4360	7	5.17	0	0.00	.999857	7010	422.36	.998815	0.74	NA
ERLTON		43800	6540	1	0.67	0	0.00	.999977	43800	6540.00	.999898	0.67	NA
STAMPEDE		138676	8720	1	0.75	0	0.00	.999923	138675	8720.00	.999914	0.75	NA
CITY HALL		59038	8720	7	5.00	0	0.00	.999881	8434	1245.71	.999427	0.71	NA
CENTER ST		161565	8720	4	3.00	0	0.00	.999975	40391	2180.00	.999656	0.75	NA
3RD ST W		144835	8720	3	2.25	0	0.00	.999979	48276	2906.67	.999742	0.75	NA
6TH ST W		75290	8720	4	2.92	0	0.00	.999947	18822	2180.00	.999666	0.73	NA
8TH ST W		71702	6540	4	2.92	0	0.00	.999944	17925	1635.00	.999554	0.73	NA
SYSTEM		1266260	89380	49	36.08	0	0.00	.999961	25842	1824.08	.999596	0.74	NA

TABLE A-5  
FRONT DOOR SUBASSEMBLY PERFORMANCE - CALGARY

LOCATION	MACHINE	TRANS	OP TIME (HRS)	TOTAL FAILS	TOTAL DOWN TIME	TOTAL HARD FAILS	TOTAL DOWN TIME HARD	R	MTF	MTBF (HRS)	A	ADT (HRS)	MTTR (HRS)
ANDERSON	1	74778	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	2	46240	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	3	40341	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	4	24363	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
SOUTHLAND	5	35004	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	7	34104	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	6	27937	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
HERITAGE	8	35384	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	9	43054	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	10	21524	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
CHINOOK	11	50623	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	12	57221	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	34	31709	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
42ND AVE	14	38012	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	13	11060	2180	3	3.75	3	3.75	.999729	3687	726.67	.998280	1.25	1.25
ERLTON	15	18999	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	16	12905	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	17	11896	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
STAMPEDE	21	24482	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	18	31823	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	19	47695	2180	1	1.17	1	1.17	.999779	47695	2180.00	.999465	1.17	1.17
	20	34676	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
CITY HALL	22	11748	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	23	9460	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	24	10310	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	25	27520	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
CENTER	29	54705	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	28	41974	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	27	22355	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	26	42531	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
3RD ST W	30	39432	2180	1	0.75	1	0.75	.999775	39432	2180.00	.999656	0.75	0.75
	31	38939	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	32	22338	2180	1	0.75	1	0.75	.999955	22338	2180.00	.999656	0.75	0.75
	33	44126	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
6TH ST W	35	29979	2180	1	0.75	1	0.75	.999967	29979	2180.00	.999656	0.75	0.75
	36	3638	2180	1	0.75	1	0.75	.999884	3638	2180.00	.999656	0.75	0.75
	37	12306	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	38	24367	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
8TH ST W	39	44406	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	40	17238	2180	1	1.17	1	1.17	.999942	17238	2180.00	.999465	1.17	1.17
	41	10058	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
SUMMARY													
ANDERSON		185722	8720	0	0.00	0	0.00	1	NA	NA	1	NA	NA
SOUTHLAND		97045	6540	0	0.00	0	0.00	1	NA	NA	1	NA	NA
HERITAGE		99962	6540	0	0.00	0	0.00	1	NA	NA	1	NA	NA
CHINOOK		139553	6540	0	0.00	0	0.00	1	NA	NA	1	NA	NA
42ND AVE		49072	4360	3	3.75	3	3.75	.999939	16357	1453.33	.999140	1.25	1.25
ERLTON		43800	6540	0	0.00	0	0.00	1	NA	NA	1	NA	NA
STAMPEDE		138676	8720	1	1.17	1	1.17	.999993	138675	8720.00	.999866	1.17	1.17
CITY HALL		59038	8720	0	0.00	0	0.00	1	NA	NA	1	NA	NA
CENTER ST		161565	8720	0	0.00	0	0.00	1	NA	NA	1	NA	NA
3RD ST W		144835	8720	2	1.50	2	1.50	.999936	72417	4360.00	.999828	0.75	0.75
6TH ST W		75290	8720	2	1.50	2	1.50	.999973	37645	4360.00	.999828	0.75	0.75
8TH ST W		71702	6540	1	1.17	1	1.17	.999936	71702	6540.00	.999822	1.17	1.17
SYSTEM		1266260	89380	9	9.08	9	9.08	.999993	140694	9931.11	.999898	1.01	1.01

TABLE A-6  
BATTERY AND CHARGER PERFORMANCE - CALGARY

LOCATION	MACHINE	TRANS	OP TIME (HRS)	TOTAL FAILS	TOTAL DOWN TIME	TOTAL HARD FAILS	TOTAL DOWN TIME HARD	R	MTF	MTBF (HRS)	A	ADT (HRS)	MTTR (HRS)
ANDERSON	1	74778	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	2	46240	2180	1	0.75	1	0.75	.999978	46240	2180.00	.999656	0.75	0.75
	3	40341	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	4	24363	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
SOUTHLAND	5	35004	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	7	34104	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	6	27937	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
HERITAGE	8	35384	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	9	43054	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	10	21524	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
CHINOOK	11	50623	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	12	57221	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	34	31709	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
42ND AVE	14	38012	2180	1	0.75	1	0.75	.999974	38012	2180.00	.999656	0.75	0.75
	13	11060	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
ERLTON	15	18999	2180	1	0.75	1	0.75	.999947	18999	2180.00	.999656	0.75	0.75
	16	12905	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	17	11896	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
STAMPEDE	21	24482	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	18	31823	2180	1	0.75	1	0.75	.999969	31823	2180.00	.999656	0.75	0.75
	19	47695	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	20	34676	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
CITY HALL	22	11748	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	23	9460	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	24	10310	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	25	27520	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
CENTER	29	54705	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	28	41974	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	27	22355	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	26	42531	2180	1	0.75	1	0.75	.999976	42531	2180.00	.999656	0.75	0.75
3RD ST W	30	39432	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	31	38939	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	32	22338	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	33	44126	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
6TH ST W	35	29979	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	36	8638	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	37	12306	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	38	24367	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
8TH ST W	39	44406	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	40	17238	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	41	10058	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA

SUMMARY

ANDERSON	185722	8720	1	0.75	1	0.75	.999995	185722	8720.00	.999914	0.75	0.75
SOUTHLAND	97045	6540	0	0.00	0	0.00	1	NA	NA	1	NA	NA
HERITAGE	99962	6540	0	0.00	0	0.00	1	NA	NA	1	NA	NA
CHINOOK	139553	6540	0	0.00	0	0.00	1	NA	NA	1	NA	NA
42ND AVE	49072	4360	1	0.75	1	0.75	.999980	49072	4360.00	.999828	0.75	0.75
ERLTON	43800	6540	1	0.75	1	0.75	.999977	43800	6540.00	.999885	0.75	0.75
STAMPEDE	138676	8720	1	0.75	1	0.75	.999993	138675	8720.00	.999914	0.75	0.75
CITY HALL	59038	8720	0	0.00	0	0.00	1	NA	NA	1	NA	NA
CENTER ST	161565	8720	1	0.75	1	0.75	.999994	161564	8720.00	.999914	0.75	0.75
3RD ST W	144835	8720	0	0.00	0	0.00	1	NA	NA	1	NA	NA
6TH ST W	75290	8720	0	0.00	0	0.00	1	NA	NA	1	NA	NA
8TH ST W	71702	6540	0	0.00	0	0.00	1	NA	NA	1	NA	NA
SYSTEM	1266260	89380	5	3.75	5	3.75	.999996	253248	17876.00	.999958	0.75	0.75



TABLE A-7  
CASH BOX PERFORMANCE - CALGARY

LOCATION	MACHINE	TRANS	OP TIME (HRS)	TOTAL FAILS	TOTAL DOWN TIME	TOTAL HARD FAILS	TOTAL DOWN TIME HARD	R	MTF	MTBF (HRS)	A	ADT (HRS)	MTTR (HRS)
ANDERSON	1	74778	2180	7	4.67	0	0.00	.999906	10683	311.43	.997859	0.67	NA
	2	46240	2180	3	2.00	0	0.00	.999935	15413	726.67	.999083	0.67	NA
	3	40341	2180	2	1.33	0	0.00	.999950	20170	1090.00	.999388	0.67	NA
	4	24363	2180	4	2.67	0	0.00	.999836	6091	545.00	.998777	0.67	NA
SOUTHLAND	5	35004	2180	0	0.00	0	0.00	.999941	NA	NA	1	NA	NA
	7	34104	2180	2	1.33	0	0.00	.999975	17052	1090.00	.999388	0.67	NA
	6	27937	2180	6	4.00	0	0.00	.999785	4656	363.33	.998165	0.67	NA
HERITAGE	8	35384	2180	1	0.67	0	0.00	.999972	35384	2180.00	.999694	0.67	NA
	9	43054	2180	2	1.33	0	0.00	.999954	21527	1090.00	.999388	0.67	NA
	10	21524	2180	4	2.67	0	0.00	.999814	5381	545.00	.998777	0.67	NA
CHINOOK	11	50623	2180	1	0.67	0	0.00	.999980	50623	2180.00	.999694	0.67	NA
	12	57221	2180	2	1.33	0	0.00	.999965	28610	1090.00	.999388	0.67	NA
	34	31709	2180	6	4.00	0	0.00	.999811	5285	363.33	.998165	0.67	NA
42ND AVE	14	38012	2180	1	0.67	0	0.00	.999974	38012	2180.00	.999694	0.67	NA
	13	11060	2180	2	1.33	0	0.00	.999819	5530	1090.00	.999388	0.67	NA
ERLTON	15	18999	2180	1	0.67	0	0.00	.999947	18999	2180.00	.999694	0.67	NA
	16	12905	2180	2	1.33	0	0.00	.999845	6452	1090.00	.999388	0.67	NA
	17	11896	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
STAMPEDE	21	24482	2180	2	1.33	0	0.00	.999918	12241	1090.00	.999388	0.67	NA
	18	31823	2180	7	4.67	0	0.00	.999780	4546	311.43	.997859	0.67	NA
	19	47695	2180	4	2.67	0	0.00	.999916	11924	545.00	.998777	0.67	NA
	20	34676	2180	4	2.67	0	0.00	.999885	8669	545.00	.998777	0.67	NA
CITY HALL	22	11748	2180	1	0.67	0	0.00	.999915	11748	2180.00	.999694	0.67	NA
	23	9460	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	24	10310	2180	7	4.67	0	0.00	.999321	1473	311.43	.997859	0.67	NA
	25	27520	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
CENTER	29	54705	2180	2	1.33	0	0.00	.999963	27352	1090.00	.999388	0.67	NA
	28	41974	2180	6	4.00	0	0.00	.999857	6996	363.33	.998165	0.67	NA
	27	22355	2180	5	3.33	0	0.00	.999776	4471	436.00	.998471	0.67	NA
	26	42531	2180	2	1.33	0	0.00	.999953	21265	1090.00	.999388	0.67	NA
3RD ST W	30	39432	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	31	38939	2180	1	0.67	0	0.00	.999974	38939	2180.00	.999694	0.67	NA
	32	22338	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	33	44126	2180	5	3.33	0	0.00	.999887	8825	436.00	.998471	0.67	NA
6TH ST W	35	29979	2180	1	0.67	0	0.00	.999967	29979	2180.00	.999694	0.67	NA
	36	8638	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
	37	12306	2180	2	1.33	0	0.00	.999837	6155	1090.00	.999388	0.67	NA
	38	24367	2180	4	2.67	0	0.00	.999836	6092	545.00	.998777	0.67	NA
8TH ST W	39	44406	2180	2	1.33	0	0.00	.999955	22203	1090.00	.999388	0.67	NA
	40	17238	2180	1	0.67	0	0.00	.999942	17238	2180.00	.999694	0.67	NA
	41	10058	2180	0	0.00	0	0.00	1	NA	NA	1	NA	NA
SUMMARY													
ANDERSON	185722	3720	16	10.67	0	0.00	.999914	11608	545.00	.998777	0.67	NA	NA
SOUTHLAND	97045	6540	8	5.33	0	0.00	.999918	12131	317.50	.999185	0.67	NA	NA
HERITAGE	99962	6540	7	4.67	0	0.00	.999930	14280	934.29	.999286	0.67	NA	NA
CHINOOK	139953	6540	9	6.00	0	0.00	.999936	15506	726.67	.999083	0.67	NA	NA
42ND AVE	49072	4360	3	2.00	0	0.00	.999939	16357	1453.33	.999541	0.67	NA	NA
ERLTON	43800	6540	3	2.00	0	0.00	.999932	14606	2180.00	.999694	0.67	NA	NA
STAMPEDE	198676	3720	17	11.33	0	0.00	.999877	8157	512.94	.998700	0.67	NA	NA
CITY HALL	59038	3720	8	5.33	0	0.00	.999864	7380	1090.00	.999388	0.67	NA	NA
CENTER ST	161565	3720	15	10.00	0	0.00	.999907	10771	531.33	.998853	0.67	NA	NA
3RD ST W	144835	3720	6	4.00	0	0.00	.999959	24139	1453.33	.999541	0.67	NA	NA
6TH ST W	75290	3720	7	4.67	0	0.00	.999907	10756	1245.71	.999465	0.67	NA	NA
8TH ST W	71702	6540	3	2.00	0	0.00	.999958	23901	2180.00	.999694	0.67	NA	NA
SYSTEM	1266260	89380	102	68.00	0	0.00	.999919	12414	876.27	.999239	0.67	NA	NA



APPENDIX B

EDMONTON DETAILED PERFORMANCE STATISTICS



**TABLE B-1  
ELECTRONIC CHASSIS PERFORMANCE - EDMONTON**

STATION	TRANS	FAILS	OP TIME (HRS)	DOWN TIME (HRS)	HARD FAILS	HARD DOWN TIME (HRS)	R	MTF	MTBF (HRS)	A	ADT (HRS)	MTTR (HRS)
CENTRAL	774633	4	16560	3.67	3	3.00	.99999	193656	4140	.99970	0.92	1.00
COLISEUM	523251	0	12000	0.00	0	0.00	1	NA	NA	1	NA	NA
STADIUM	331580	0	12000	0.00	0	0.00	1	NA	NA	1	NA	NA
CHURCHILL	670055	5	16560	4.67	4	4.00	.99999	134011	3312	.99972	0.93	1.00
BELVEDERE	415802	5	5520	3.67	1	1.00	.99999	83160	1104	.99934	0.73	1.00
CLAREVIEW	258701	5	9200	4.00	2	2.00	.99998	51740	1040	.99957	0.80	1.00
SYSTEM	2974022	19	73600	16.00	10	10.00	.99999	156526	3874	.99972	0.84	1.00

**TABLE B-2  
COIN MECHANISM PERFORMANCE - EDMONTON**

STATION	TRANS	FAILS	OP TIME (HRS)	DOWN TIME (HRS)	HARD FAILS	HARD DOWN TIME (HRS)	R	MTF	MTBF (HRS)	A	ADT (HRS)	MTTR (HRS)
CENTRAL	774633	66	16560	45.50	10	13.50	.99991	11737	251	.99725	0.69	0.75
COLISEUM	523251	57	12000	38.83	13	9.50	.99989	9180	226	.99698	0.63	0.73
STADIUM	331580	43	12000	29.50	10	7.50	.99987	7711	300	.99771	0.67	0.75
CHURCHILL	670055	23	16560	16.17	6	4.83	.99997	29133	720	.99902	0.70	0.81
BELVEDERE	415802	35	5520	24.00	8	6.00	.99992	11880	150	.99565	0.65	0.75
CLAREVIEW	258701	63	9200	43.33	10	3.00	.99976	4106	146	.99529	0.69	0.80
SYSTEM	2974022	237	73600	197.33	65	49.33	.99990	10362	256	.99732	0.69	0.76

**TABLE B-3  
TICKET DISPENSER PERFORMANCE - EDMONTON**

STATION	TRANS	FAILS	OP TIME (HRS)	DOWN TIME (HRS)	HARD FAILS	HARD DOWN TIME (HRS)	R	MTF	MTBF (HRS)	A	ADT (HRS)	MTTR (HRS)
CENTRAL	774633	176	16560	119.33	2	2.00	.99977	4352	73	.99279	0.67	1.00
COLISEUM	523251	73	12000	52.33	1	1.00	.99985	6708	165	.99594	0.67	1.00
STADIUM	331580	56	12000	39.33	2	2.00	.99983	5717	222	.99695	0.68	1.00
CHURCHILL	670055	71	16560	48.33	3	3.00	.99989	9437	233	.99708	0.63	1.00
BELVEDERE	415802	68	5520	46.00	2	2.00	.99984	6115	81	.99167	0.68	1.00
CLAREVIEW	258701	60	9200	40.00	0	0.00	.99977	4312	153	.99565	0.67	NA
SYSTEM	2974022	510	73600	345.33	10	10.00	.99983	5797	143	.99531	0.67	1.00

TABLE B-4  
CASH STORAGE SUBSYSTEM PERFORMANCE - EDMONTON

STATION	TRANS	FAILS	OP TIME (HRS)	DOWN TIME (HRS)	HARD FAILS	HARD DOWN TIME (HRS)	R	MTF	MTBF (HRS)	A	ADT (HRS)	MTTR (HRS)
CENTRAL	774633	5	16560	3.33	5	3.33	.99999	154926	3312	.99980	0.67	0.67
COLISEUM	523251	5	12880	3.33	5	3.33	.99999	104650	2576	.99974	0.67	0.67
STADIUM	331580	2	12880	1.33	2	1.33	.99999	165788	6440	.99990	0.67	0.67
CHURCHILL	670055	0	16560	0.00	0	0.00	1	NA	NA	1	NA	NA
BELVEDERE	415802	1	5520	0.67	1	0.67	1	415800	5520	.99988	0.67	0.67
CLAREVIEW	258701	2	9200	1.33	2	1.33	.99999	129349	4600	.99986	0.67	0.67
SYSTEM	2974022	15	73600	10.00	15	10.00	.99999	198267	4907	.99986	0.67	0.67

TABLE B-5  
ELECTRICAL SUBSYSTEM PERFORMANCE - EDMONTON

STATION	TRANS	FAILS	OP TIME (HRS)	DOWN TIME (HRS)	HARD FAILS	HARD DOWN TIME (HRS)	R	MTF	MTBF (HRS)	A	ADT (HRS)	MTTR (HRS)
CENTRAL	774633	19	16560	12.67	19	12.67	.99998	40770	872	.99924	0.67	0.67
COLISEUM	523251	6	12880	4.33	6	4.33	.99999	87208	2147	.99966	0.72	0.72
STADIUM	331580	12	12880	8.00	12	8.00	.99996	27632	1073	.99938	0.67	0.67
CHURCHILL	670055	11	16560	8.00	11	8.00	.99998	60914	1505	.99952	0.73	0.73
BELVEDERE	415802	3	5520	2.33	3	2.33	.99999	138600	1840	.99958	0.78	0.78
CLAREVIEW	258701	10	9200	7.67	10	7.67	.99996	25870	920	.99917	0.77	0.77
SYSTEM	2974022	61	73600	43.00	61	43.00	.99998	48754	1207	.99942	0.70	0.70

TABLE B-6  
MISCELLANEOUS PERFORMANCE - EDMONTON

STATION	TRANS	FAILS	OP TIME (HRS)	DOWN TIME (HRS)	HARD FAILS	HARD DOWN TIME (HRS)	R	MTF	MTBF (HRS)	A	ADT (HRS)	MTTR (HRS)
CENTRAL	774633	6	16560	6.00	6	6.00	.99999	129104	2760	.99964	1.00	1.00
COLISEUM	523251	3	12880	3.00	3	3.00	.99999	174417	4293	.99977	1.00	1.00
STADIUM	331580	7	12880	7.00	7	7.00	.99998	47368	1840	.99946	1.00	1.00
CHURCHILL	670055	9	16560	9.00	9	9.00	.99999	74450	1840	.99946	1.00	1.00
BELVEDERE	415802	3	5520	3.00	3	3.00	.99999	138600	1840	.99946	1.00	1.00
CLAREVIEW	258701	2	9200	2.00	2	2.00	.99999	129349	4600	.99978	1.00	1.00
SYSTEM	2974022	30	73600	30.00	30	30.00	.99999	99134	2453	.99959	1.00	1.00

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