DOT-TSC-UMTA-83-2

U.S. Department
of Transportation

**Urban Mass
Transportation
Administration**

Wheelchair Lifts on Transit Buses

Prepared by:
Ketron Inc.

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DEPARTMENT

Technical Assistance - an UMTA Program

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of Transportation

**Urban Mass
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Wheelchair Lifts on Transit Buses

Summary of U. S. Experience

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PREFACE

This project was conducted for the USDOT Transportation Systems Center (TSC) and the Urban Mass Transportation Administration (UMTA) by KETRON, Inc. - Cambridge Facility. The contract was initiated in September, 1980 between TSC and Applied Resource Integration, Ltd. (ARI) of Boston - Contract No. DTRS57-80-C-00150. In 1981 KETRON acquired ARI and the project was continued and completed by the same project team.

The successful completion of the project is attributable to the cooperation of a large number of organizations and personnel representing transit properties, bus manufacturers, lift suppliers, and others concerned with the problem of accessibility on public transit systems. The authors wish to thank all of the individuals who have contributed their time and information to the study effort and to Deborah Burke for her efforts in the typing and preparation of the report.

The UMTA Project Sponsor was Mr. John Goon of the Office of Technology Development and Deployment. Project monitoring and guidance was provided by Mr. Stuart Palonen and Mr. Richard Porcaro of TSC. Overall project management and inputs to the study were provided by Mr. Richard Robichaud and Dr. Donald Sussman of TSC.

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APPENDIX A

SECTION 1
EXECUTIVE SUMMARY

The overall objective of the project was to develop information and guidance for the transit industry concerning wheelchair lifts on transit buses in the areas of lift procurement, testing and acceptance, training, and maintenance. The methodology for the project included the conduct of a nationwide survey/inventory of lifts, the buses equipped with them, and the transit properties operating them. Based on the inventory, thirteen properties were selected for on-site collection of data and experiences with lift performance in transit service. The project scope was limited to an examination of passive-type lifts installed in heavy duty transit buses providing fixed route service. A passive lift is defined as one which forms a conventional step entryway when in the stored or stowed position. Seven manufacturers with passive lifts installed in heavy duty transit buses were identified. In descending order of market share, the lift manufacturers were:

		Market Share (Up to Spring 1981)
o	General Motors Corporation	45%
o	Environmental Equipment Corporation	27%
o	Transportation Design & Technology, Inc.	16%
o	Lift-U, Inc.	11%
o	Vapor Corporation	11%
o	TransiLift Equipment, Ltd.	<1%
o	Collins Industries, Inc.	<1%

These lifts were installed or in production for 11 different manufacturers of buses, predominantly for original equipment installation. At the end of 1980, there were over 100 transit properties with accessible service. Due to the impact of state and local accessibility mandates, the geographical distribution of lift-equipped buses was not uniform. California accounted for 25% of the operators and 30% of accessible fixed route transit buses nationwide. California and Michigan together represented nearly half the accessible bus population.

Selection of the sites was based upon a number of criteria including:

- experience with the latest model for all lifts;
- original equipment and retrofit situations;
- length of service and community committment to accessibility;
- represent all major transit bus manufacturers;
- size of transit operation;
- climatic and environment factors; and
- availability of data.

A number of general problems with lifts in transit were identified through the on-site assessment process.

- Buses were jacked up by the lift due to failures or inadequate design of ground contact sensors. Many lift damage failures resulted from jacking of the bus.
- Microswitches used in lifts were too sensitive for the environment, resulting in a continual need for replacement or adjustment.
- Poor sealing of the lift in the stowed position contributed to microswitch problems and had an advance impact on the internal environment in the bus.
- Bus doors were not fully open and interfered with lift deployment.
- The cost of some replacement components were very expensive, therefore these few items would often control overall parts cost.

Other more localized problems were identified:

- Corrosion problems induced by salt and snow in front door lifts. Most lift installations preclude the use of existing stepwell heating systems.
- Corrosion problems or increased maintenance requirements in rear door installations due to use of rear stepwells as a latrine in metropolitan areas.

A number of operational need and problems were identified.

- A need for maximum simplicity of lift operating controls because many drivers lose familiarity with the lift due to low ridership. Daily cycling by the driver is not believed to be practical at many larger properties.
- Lack of refresher training to enhance driver familiarity.
- A need to minimize routine maintenance requirements and realistically tailor them to practices within the industry which are based on bus mileage.
- Maintenance activities could be facilitated by providing a remote control for lift operation from outside of the bus. This is particularly true where buses are serviced on hoists.
- The size and maneuverability limitations of powered wheelchairs have been problems in many lift installations.

Two positive items should be noted. Apart from a few isolated instances, there have been no major structural failures or personal accident/injury problems with the lifts studied in this project.

Solutions to a number of the problem and need areas have been developed in the form of guidelines and recommendations.

- Specify ground sensing systems for lifts which preclude jacking the bus by defining the platform area to be sensed and size of local protrusion (e.g. stone, road camber) to be tolerated.
- Incorporate a failure path which will prevent major damage to the lift or bus if the ground contact system fails and the bus is jacked.
- Minimize the number of microswitches used.
- Minimize the number of proprietary and costly components.
- Design components for repair rather than replacement.
- Design the lift platform to accommodate a powered wheelchair facing in either direction with the safety barriers raised.
- Design the lift platform to always maintain a horizontal or slightly positive angle of inclination under loaded conditions to avoid the problem of a wheelchair inadvertently rolling off the lift.

- Conduct lift tests on a complete bus installation and include low temperature lift tests (-20°F) and corrosive (salt) environments or atmospheres. Jacking situations should be simulated.
- Endurance tests should reflect actual lift usage which is unlikely to exceed one to two passengers per day on an average basis.
- Vehicle endurance tests should include crossing of crowned intersections and curb approaches at typical bus operating speeds.
- Lift procurement specifications should include:
  - a statement of the operator's major servicing intervals and procedures and a request that lift maintenance requirements correspond;
  - a statement of the climatic environment and road conditions with a requirement for identification of three properties using the lift under similar conditions to be used for reference purposes;
  - a requirement that a recommended spare parts inventory and associated costs be stated; and
  - a requirement that special lift parts which cannot be rebuilt be identified.
- Procurement specifications should also require ground contact limitations and ground contact sensor failure to be demonstrated or attested to as part of the acceptance testing.

During the project, the scope of work was amended to include an evaluation of transit property experiences with wheelchair restraint systems and interior layouts. The wheelchair restraint results were presented in a separate Project Memorandum. The major finding was that increasing use of powered chairs requires careful consideration in interior arrangements and restraint system design. The most widely used types of wheel clamp restraints are inadequate for powered chairs.

In summary, the overall experience of the transit industry using lift-equipped buses in fixed route service has been satisfactory. Lift performance appeared to always improve in those situations where ridership was high, lifts were frequently used and cycled, and where the entire operation was committed to the concept of fixed route accessibility.

SECTION 2
BACKGROUND

The use of lift-equipped buses in fixed route transit service and the types of equipment used resulted from a number of parallel and interactive social, legislative, and technological developments which occurred in the late 1970's. These developments were instrumental in establishing the requirements for this project, and as a result, they are discussed in this section along with the project methodology and activities to provide a comprehensive background for the project results.

2.1 SECTION 504 REGULATIONS

Section 504 of the Rehabilitation Act of 1973 required that all recipients of federal financial assistance make existing and future facilities and programs accessible to handicapped persons so they can effectively use these facilities and programs. The United States Department of Transportation (DOT) issued proposed regulations for compliance with Section 504 on June 8, 1978 and in that notice requested that all interested parties comment on their regulation. The regulations were finalized on May 31, 1979 and established the manner by which public transportation systems receiving federal support would provide accessible service to handicapped persons.

DOT's regulations set specific time frames for compliance, indicated what must be done to facilities to accomplish program accessibility, and set the minimum amount of funding for interim services if compliance was not achieved within a certain period. In addition, DOT mandated that each recipient of federal monies prepare an annually updated transition plan which illustrated the manner in which program accessibility would be achieved. These first transition plans were to be completed by July 1, 1980 for bus only cities and six months later for bus and rail cities and had to be developed in conjunction with, and approved by, a local handicapped advisory group.

Except for fixed facilities for the public and system policies/practices, each mass transit mode had a separate set of criteria for program accessibility compliance. Fixed route bus systems achieved program accessibility by equipping one-half of the peak hour fleet with lifts within a three year period (July 1, 1982). The time period could be extended to ten years (July 1, 1989) if extreme financial hardship was proven. In addition, all fixed route buses of any size purchased after July 2, 1979 were to be accessible. The deployment of accessible vehicles was also addressed in the regulations. During the peak period, one-half the fleet was accessible and in the base period, accessible vehicles were to be in revenue service prior to any use of inaccessible ones.

While some states, such as California and Michigan, already had requirements for purchasing accessible buses, it was evident that the Federal mandate would further accelerate the purchase and operational deployment of such equipment.

USDOT amended the regulations in July, 1981 to remove the requirements for phased accessibility modification of public transit facilities and services. The revised regulations reinstituted earlier "Special Efforts" type of regulations which provide transit properties with much greater flexibility in determining their handicapped transportation programs. Thus, transit properties may choose to use lift-equipped buses or demand responsive paratransit or some combination of both. Even with this relaxation in federal regulations the net effect of the accessibility mandates over the years has been to place relatively large numbers of lift-equipped transit buses into the fleets of properties throughout the country.

2.2 LIFT HISTORY

The development and use of the passenger lift for non-ambulatory transit passengers represents the culmination of major efforts to improve the physical accessibility of transit vehicles. The aim of these efforts has been to mitigate or eliminate the need to use steps to enter and leave the bus. Approaches have included lowering the bus floor, raising the sidewalk at bus stops, and mechanical alternatives to the existing steps including the use of ramps and lifts.

2.2.1 Low Floors

The design of a low floor bus was a primary objective of the Transbus program to accomodate a ramp for walk-in or wheel-in entry for all passengers. Lower floors were incorporated in the prototypes produced by all three companies participating in the Transbus program, AMG, Flxible, and GMC; floor heights were in the 22 to 24 inch height range which resulted in the elimination of one step. The

Flxible buses which had the lowest floor incorporated a ramp which provided acceptable angles for wheelchair entry. Transit industry concerns about loss of passenger capacity and reduced ground clearance eventually forced a retreat from these specifications to the more moderate standards of the Advanced Design Bus Specifications (ADB). A lower floor height, while reducing the number and/or height of interior steps, does not control the height of the first step from ground to the bus. For the conventional transit bus with its doorway ahead of the front wheels, this height is set by the approach angle (generally, nine or ten degrees) necessary to provide adequate road and operational clearances. This approach angle sets the first step height at 13 to 14 inches above the ground which is excessive for many persons unless the bus is at a curb. To address this problem, the concept of kneeling the bus by deflating the front suspension air bags was introduced and adopted into all UMTA sponsored bus purchases in 1977. As a result of this, the first step height was reduced to a size consistent with the interior ones, but the entryway remained a stepped one.

2.2.2 Raised Platforms

The approach of providing a raised platform to allow level entry similar to rapid transit systems has been explored experimentally; however, the limitations imposed by the diversity of bus stop locations, conditions, and the capital investment involved has prevented any practical application of the concept. Another technical problem involves the maneuvering of the bus to the platform area. In Europe, experiments have been undertaken with guidance control systems to automatically steer the bus to the platform. American developments have centered upon providing a bridging platform within the vehicle to cross any gap between the raised platform and the bus. The AMG Transbus prototypes featured bridging a device capable of lateral movement, but without any substantial vertical capability. The Flxible Transbus prototype featured a short extending ramp which could also have been used in these situations.

2.2.3 Ramps

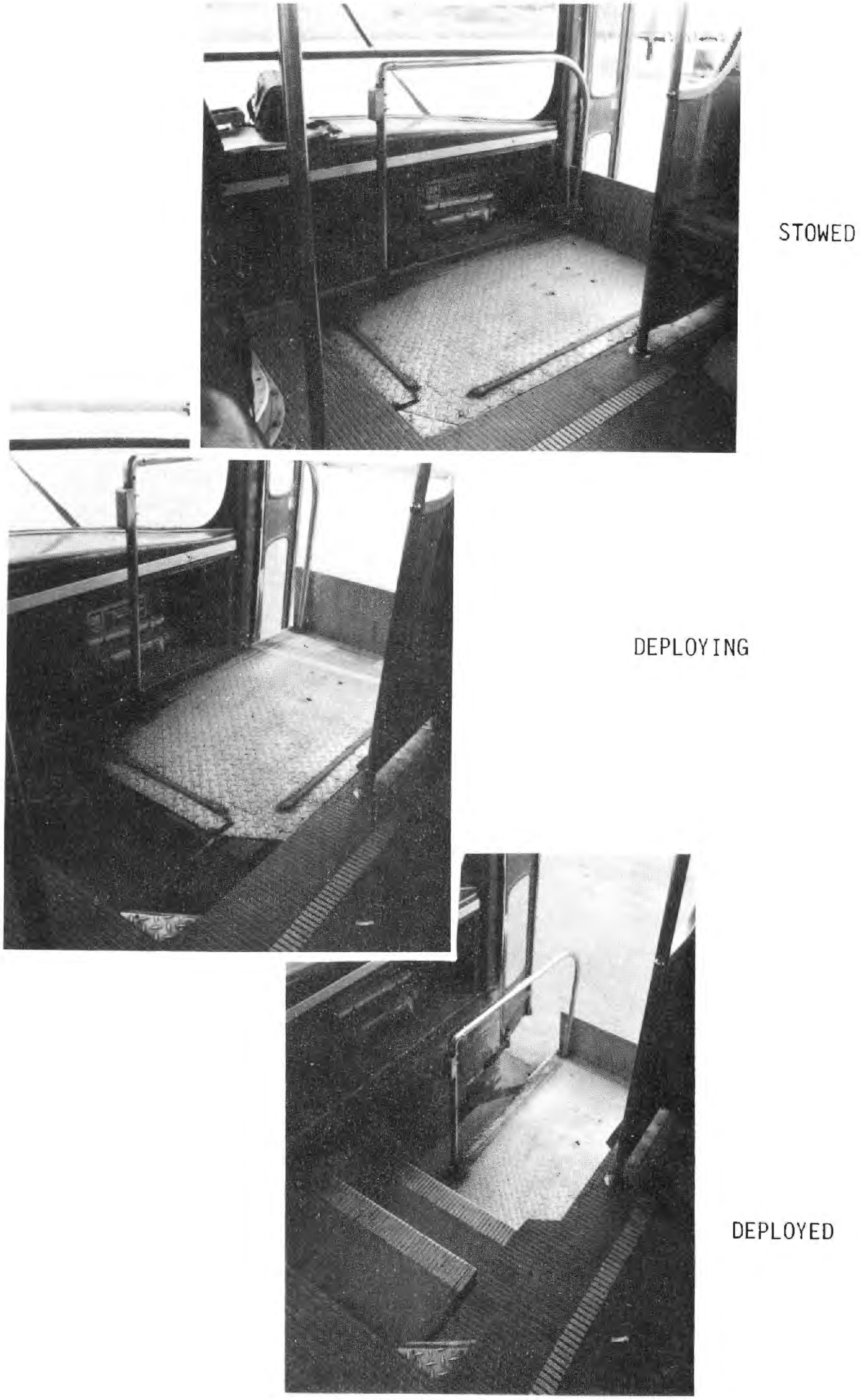
Because of the diversity of operational situations encountered, bus accessibility improvements have primarily involved ramps or lifts installed in the bus. The ramp has been attractive because of its mechanical simplicity, but in practice, the ramp length necessary to provide gentle slopes which allow use by a manual wheelchair, and stable operation by all chairs, have proven to be excessive. A shorter ramp can be used with some form of powered assistance. A prototype power-assist ramp has been tested at the Southern California Rapid Transit District (SCRTD) in Los Angeles as shown in Figure 2.2-1. A six foot (two piece) folding ramp was stored directly ahead of the front door and was operated in conjunction with a power operated winch. The winch moved a cable which was attached to a harness that secured the wheelchair. Cable speed was 15 to 20 feet per minute. Testing of the system demonstrated that it was too slow and cumbersome for transit use.

2.2.4 Passenger Lifts

The primary form of providing transit bus access for the non-ambulatory has been in the development of passenger lifts. These are principally intended for use by wheelchair confined persons, but depending on the lift design and the operator's procedures they can be used by the semi-ambulatory. Semi-ambulatory persons include those who use aids such as canes, crutches, and walkers for assistance in moving about. Lifts are commercially available from a number of manufacturers and are generically classified under two categories: active and passive. Active lifts for fixed route transit bus service are those which must be activated at all stops if it is placed in a doorway which must be used by all passengers. Figure 2.2-2 shows an active lift (manufactured by Blitz) installed in the front door of a GMC transit bus. Active lifts also include those which are installed on paratransit vehicles. This type of active lift is a relatively simple device with a one-piece fold-up platform which is usually manually extended or retracted and is raised hydraulically or electrically. They evolved from the personal lifts used to convert vans for operation by handicapped drivers. Active lifts are extensively used in paratransit vehicles providing specialized elderly and handicapped services which generally have a relatively low occupancy ratio. Thus, the separate entryway required by this type of lift can be provided without unduly compromising the operational efficiency of the vehicle. This type of lift has also been installed in the rear door of a number of transit type vehicles which have been converted to carry large groups of handicapped persons.

Passive lifts are those which form a conventional step entry when the lift is in the stored or stowed position. They are efficient for transit bus use since there is no loss in seating capacity or space utilization. Current passive lifts

FIGURE 2.2-1: PROTOTYPE RAMP AND WINCH INSTALLATION AT SCRTD,
LOS ANGELES, CALIFORNIA



STOWED

DEPLOYING

DEPLOYED

FIGURE 2.2-2: FRONT DOOR INSTALLATION OF ACTIVE LIFT (BLITZ) IN TRANSIT BUS either deploy a platform which also forms the bottom step or they use a mechanical linkage to collapse the step treads and risers into a flat platform. Figure 2.2-3 illustrates the latter concept. Some lifts combine features of both systems. All passive lifts use a separate system to raise and lower the platform between bus floor and ground level.

Development of these devices began in the mid 1970's, with the first applications to full size transit buses involving relatively small numbers of lifts retrofitted into existing vehicles. This included Atlanta, Georgia where 17 vehicles were run on special fixed routes dedicated to handicapped patrons and San Diego, California where six buses were used in regular fixed route services. The first order of lift-equipped buses supplied by a manufacturer was in 1977 for 157 buses supplied by Flxible to the Bi-State Development Agency in St. Louis, Missouri. Subsequently, sizable orders were placed with Flxible by operators in Milwaukee, Wisconsin, and Washington, D.C.; in addition, SCRTD ordered 200 accessible vehicles from American Motors General Corp. (AMG). Many of these orders were triggered by local concerns over accessibility, as well as the need to fulfill federal and state statutory requirements.

2.3 LIFT ASSESSMENT PROJECT

Preliminary results from the introduction of large numbers of lift-equipped buses into transit bus fleets throughout the country indicated that there were problems in the areas of lift maintenance and reliability. The severity of the problems and their causes could not be easily identified since there was no central focus or source of information and any available data was not consistent from property to property. The USDOT through it's Transportation Systems Center (TSC) decided to conduct a comprehensive national assessment of the experiences of transit properties with lift-equipped buses. KETRON, Inc. (formerly Applied Resource Integration, Ltd.) was selected in September, 1980 to conduct an engineering assessment and safety evaluation of the wheelchair lifts used on transit buses, based upon the operational experiences and data records of selected transit properties.

The overall project methodology was based on the development of a data base on existing lift equipment and accessible bus operations which would be used to determine the existing state-of-the-art in lift technology through site visits to

STOWED

DEPLOYED

FIGURE 2.2-3: EXAMPLE OF A PASSIVE LIFT (VAPOR) INSTALLATION IN A BUS selected transit operations. To do this, the project was divided into two phases. Phase I covered an inventory of lifts, bus installations, and transit operators; development of assessment and site selection criteria; and selection of sites for data collection. Phase I was completed in the Fall of 1980 and a report* was issued covering all task activities. Highlights of the Phase I results are presented in this section to provide background information.

Phase II covered visits to the selected transit properties, analysis of the data collected and development of this final project report including conclusions and recommendations. Phase II activities and results are documented in the subsequent chapters of this report.

2.3.1 Inventory of Passenger Lift-Equipped Transit Buses

Data for the inventory was derived from three sources: wheelchair lift equipment manufacturers; transit bus manufacturers; and transit properties. Seven manufacturers of passive lifts used in heavy duty transit bus service were identified, and in alphabetical order they are:

- Collins Industries, Inc. of Hutchinson, Kansas;
- Environmental Equipment Corporation (EEC) of San Leandro, California;
- General Motors Corporation, Truck and Coach Division, Pontiac, Michigan;
- Lift-U, Inc. of Seattle, Washington;
- TransiLift Equipment of Calgary, Alberta, Canada;
- Transportation Design and Technology (TDT) of San Diego, California; and
- Vapor Corporation of Niles, Illinois.

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* "Evaluation and Assessment of Wheelchair Lifts on Public Transit Buses - Phase I Report Inventory and Site Selection," Report No. DOT-TSC-UM229-PM-81-54, October, 1981.

The overall characteristics of the lifts are shown in Table 2.3-1. These lifts were identified along with eleven bus manufacturers, of which ten remained as active producers. The other, American Motors General Corporation, had withdrawn from the marketplace two years earlier. A number of the manufacturers had not yet delivered vehicles with lifts. Included among these were a number of European based companies particularly those offering articulated buses. Table 2.3-2 shows the various combinations that were found and whether they were fitted as original equipment, as retrofits, or as demonstrator or prototype installations.

The wheelchair lift manufacturer was used as the primary variable for tabulating information because the variations between the various lift designs were felt to be the most significant in terms of lift performance. Table 2.3-3 presents the wheelchair lift manufacturers by market share which shows that GMC has been the largest supplier of lifts. This situation is due to the fact that GMC manufactures and installs its own lift in the rear door of its RTS buses. This market penetration is reflected in the bus manufacturers' share of the market shown in Table 2.3-4.

In order to allow sufficient operational experience with lift-equipped buses to provide data for the Phase II assessment it was necessary to select properties where bus deliveries would be made by the end of the first quarter of 1981. This proved to be a significant factor because analysis of the manufacturers' orders showed that:

1) State and local mandates, such as those in California, Michigan and Metropolitan Seattle, had already produced many accessible services in those areas. In fact, California had 30% of the buses and 25% of the operators.

2) Because of the rush of orders prior to the July, 1979 USDOT regulation deadline, a majority of the 1980 production of ADB's were not accessible. For instance, only 40% of the Grumman-Flxible 870's produced in 1980 were lift-equipped.

3) There had been little retrofit activity up to the time of inventory with some slight increase projected in 1981.

The characteristics of the operators and time schedule for lift-equipped bus deliveries are shown by individual lift manufacturer in Appendix A.

	MANUFACTURER						
CHARACTERISTIC	GMC	EEC	TDT	VAPOR	LIFT-U	COLLINS	TRANSILIFT
Platform Length, Inches	36	46	49	50	47	40	46
Platform Width, Inches	50	30	34	34	30	42	32
Capacity, Lbs.	600	600	600* 1000**	600* 1000**	1000	1000	600* 1000**
Power Required	Hydraulic (Pwr Unknown)	Hydraulic 1½ - 2Hp	Hyd. or Elec 2 to 2½Hp	Hydraulic 2 - 3Hp	Hydraulic 2Hp	Hydraulic	Hydraulic 2Hp
Auxiliary Power Required	Elec 24 VDC Air 100 PSI	Elec.	Elec 12 VDC	Elec 12/24 VDC	Elec 12 VDC	Elec	Elec 12/24 VDC
Anti-Fold Protection	Dual Switches	Weight Sensor	Weight Sensor	***	Dual Switches	Weight Sensor	Locking Switch
Back-Up Operating Method	Hand Winch To Lift Platform	Man. Pump Separate Valve	Manual Pump	Manual Pump	Hyd. Pump and Crank	Manual Pump	Manual Pump

---

*Continuous

**Maximum

***Electronic Device Under Development

TABLE 2.3-1: CHARACTERISTICS OF THE PASSIVE LIFTS INVESTIGATED

BUS/LIFT	EEC	LIFT-U	TRANSI	TDT	VAPOR	GMC	COLLINS
AMG	R	D		0			
FLXIBLE	0(870)	D(870)		R(870)	0		
FLYER		0			0		
GMC	R			R		0(RTS-2)	
GMC (Canada)	0	R	R				
TMC/ORION			0	0			
CHANCE					0		
GILLIG		0		R			
BLUEBIRD							0
NEOPLAN				0*	0*		
IKARUS					0*		
MAN		0*			0*		

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*Not yet in service at time of inventory

0 - Original equipment
R - Retrofit
D - Demonstration/Prototype

TABLE 2.3-2: MAJOR LIFT/BUS COMBINATIONS

MAKER	%
GMC	44
EEC	27
TDT	13
LIFT-U	8
VAPOR	8
COLLINS	<1
TRANSILIFT	<1

TABLE 2.3-3: PERCENTAGE MARKET SHARE BY LIFT MAKER

MODEL	%
AMG	5
FLXIBLE (870)	27
FLXIBLE (New Look)	8
FLYER	10
GMC (RTS-2)	43
GMC (C) - (New Look)	4
TMC - Citycruiser	2
CHANCE RT-50	1
BLUEBIRD	<1

TABLE 2.3-4: PERCENTAGE MARKET SHARE BY BUS MAKER

2.3.2 Site Selection Criteria

The major criteria used in selecting the sites can be grouped under four headings as shown in Table 2.3-5. Because of the limited market share of some lifts and geographical distribution of lift-equipped buses in service it was not possible to satisfy all of the conditions simultaneously. A list of about 30 potential sites satisfying many of the criteria was prepared for review with TSC from which a final list of 13 sites was chosen.

2.3.3 Site Visit Methodology and Chronology

The selected sites were formally notified by the TSC Technical Monitor of the project by a letter which requested their cooperation and advised that they would be contacted at some future date by KETRON personnel in order to set up specific site visit plans and timings. The site visits were conducted by two senior engineers dividing the sites between them. Visits to the plants of all the major lift manufacturers were included in this phase of the program. The sites selected divided into four geographical areas centering upon the states of Michigan, Wisconsin-Illinois, California-Oregon-Washington, and Colorado-Kansas. Five working days were allowed for each site visit for a large transit operation with extensive data collection; somewhat shorter periods were used for the smaller properties. As the site visits progressed and as experience was gained, a number of factors emerged which modified the original plans or limited the data collection possibilities at some sites. A major factor was the problem of underframe cracking on the Grumman Flxible Corporation (GFC) 870 bus which forced it's withdrawal from service or delays in vehicle deliveries. As a consequence, no assessment of the GFC 870 bus with the EEC lift was possible at SCRTD as originally intended, and the data available at Champaign-Urbana and Santa Clara County was less than planned. To partially compensate for this, Grand Rapids, Michigan, which had six months of accessible service with the EEC lift on the GFC 870 bus was added to the sites visited.

Other factors included a number of delays which occurred in the deployment of some buses due to retrofit programs proceeding slower than anticipated. For instance, Denver RTD had retrofitted their AMG buses with lifts, but had not determined the final interior configuration and consequently the buses were not in accessible service. Low ridership or other constraints upon the operation of lift-

LIFT/BUS COMBINATIONS

- All Lifts
- Predominant Bus/Lift Combinations
- Latest Model Lifts
- Original Equipment and Retrofit

OPERATIONAL CONSIDERATIONS

- Front vs. Rear Door
- Fleet/Property Size Variation
- Climate Variation

EXPERIENCE CONSIDERATIONS

- Time in Service
- Accumulated Lift Use

OTHER CONSIDERATIONS

- Data Availability
- Community/Property Commitment to Accessibility
- Avoid Duplication with Other TSC Studies

TABLE 2.3-5: LIFT OPERATIONS SITE SELECTION CRITERIA equipped buses made it desirable to supplement the planned data collection with visits to other sites. For this reason it was decided that Cambria County Transit Authority, Johnstown, Pennsylvania, be added to the assessment of RTS-II lifts.

The final chronology of site visits is presented in Table 2.3-6. The first group of site visits in Michigan were conducted jointly by the two senior assessment engineers to coordinate activities and ensure similarity of approach and data formats at the other sites. This procedure was necessary because very few properties had responded with examples of in-house data and data formats as requested during initial contacts. At many sites, it was found that substantial amounts of data on repairs and parts consumption existed, but required extraction and compilation on-site which reduced the time available for collection of other data. A positive factor that emerged was KETRON's selection by Santa Clara County Transportation Agency (SCCTA) to conduct an evaluation of front and rear door lift installations. As a result of this contract effort, it was possible to supplement the SCCTA data base and to expand data available from other West Coast sites in a cost effective manner.

2.3.4 Lift Assessment Criteria

The criteria for lift assessment were grouped under three headings covering the physical characteristics of the lift, in-service performance, and safety related issues (Table 2.3-7). It was anticipated that the major effort would be in the area of in-service performance, and a list of potential data items covering this aspect was prepared as summarized in Table 2.3-8.

2.3.5 Restraint Systems

During Phase I, the scope of the lift assessment contract was amended to include an assessment of the operators' experiences with wheelchair restraint systems provided in the buses, any modifications undertaken, and safety related problems together with documentation of the layouts and system features. These were separately reported upon in a Project Memorandum.*

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* An Assessment of Wheelchair Restraint Systems used Onboard Transit Buses. KETRON, Inc. for U.S. Department of Transportation, Transportation Systems Center, Cambridge, MA, March, 1982.

PRODUCT DATA AND DESCRIPTIONS

- Lift Physical Characteristics
- Modification Data
- Lift Performance Data
- Emergency Operations

IN-SERVICE PERFORMANCE DATA

- Reliability
- Maintainability
- Availability
- Operating/Maintenance Costs

ACCIDENT AND SAFETY DATA-LIFT RELATED

- User Injuries/Complaints
- Non-User Injuries/Complaints
- Vehicle Accidents
- Safety Defects/Incidents

TABLE 2.3-6: LIFT ASSESSMENT CRITERIA

RELIABILITY

- Failure Definitions
  - Major Component Level
  - Lift Inoperable
  - Vehicle Inoperable

MAINTAINABILITY

- Maintenance/Repair Definitions
  - Preventative
  - Minor/Major Repair
- Maintenance Procedures
  - Time Requirements
  - Facilities/Skills Requirements
- Mean Time to Repair
  - Mileage/Lift Cycle/Time Base
  - Most Frequent Repair Requirement

AVAILABILITY

- Availability Definitions
  - Lift Malfunctions
  - Lift Locked Up
- Denied Boardings
  - Lift Malfunction
  - Other

LIFT OPERATING MAINTENANCE COSTS

- Based on Time Units (Labor Hours)
- Preventative Maintenance
- Repair Costs
- Road Failure Costs

TABLE 2.3-7: IN-SERVICE PERFORMANCE DATA

DATE	SITE	BUS/LIFT
6/1-5	Southeastern Michigan Transportation Authority, MI	RTS-2/GMC
6/7-9	City of Detroit - Department of Transportation, MI	RTS-2/GMC
6/11-12	Kalamazoo Metro Transit System, MI	Chance/Vapor
6/12	Grand Rapids Area Transit Authority, MI	GFC870/EEC
6/15	Blue Water Area Transportation Commission, MI	Orion/TransiLift
6/10	General Motors Corporation - Truck & Coach Division, MI	Lift Manufacturer
7/6-10	Milwaukee County Transit System, WI	Flxible/Vapor
7/13-14	Bloomington-Normal Public Transit System, IL	TMC/TDT
7/16-18	Champaign-Urbana Mass Transit District, IL	GFC870/EEC
7/12	Vapor Corporation, IL	Lift Manufacturer
7/23	Cambria County Transit Authority, PA	RTS-2/GMC
8/30-9/4*	Santa Clara County Transportation Agency, CA	GFC870/TDT
9/2*	Environmental Equipment Corporation, CA	Lift Manufacturer
7/13*	Transportation Design and Technology, CA	Lift Manufacturer
7/14*	Southern California Rapid Transit District, CA	GFC870/EEC
9/14 & 11/16*	Lane County Mass Transit District, OR	GMC (Canada)/Lift-U
9/15-18 & 21-22	Metropolitan Seattle, WA	Flyer/Lift-U
9/21	Lift-U Inc., Seattle, WA	Lift Manufacturer
9/2-8	Regional Transportation District, Denver, CO	GMC (Canada)/EEC
8/31	Collins Industries Inc., KA	Lift Manufacturer
1/13 & 11/19	Middletown Transit District, CT	Bluebird/Collins

*These visits were carried out in coordination with other KETRON project activities.

TABLE 2.3-8: CHRONOLOGY OF SITE VISITS

SECTION 3
LIFT DESCRIPTIONS

The major technical features of the lifts assessed during the project are briefly described in this section together with any significant improvement or development by the lift manufacturer resulting from a new design or specific problems experienced in the field. This is supplemented by a statement of problems reported by operators of lift-equipped buses or deduced from the site visit data. A full account of the site visit data is provided in the next section. The lift manufacturers are presented in alphabetical order.

3.1 COLLINS INDUSTRIES, INC.

3.1.1 Company Background

Collins Industries, Inc. of Hutchinson, Kansas was founded in 1972 and has four divisions, Bus, Ambulance, Fire Apparatus, and Special Products. Although it has been a major supplier of vehicles and active type lifts for paratransit vehicles for many years, the Step-Lift passive lift design is a recent development. First deliveries of the Collins Step-Lift installed on the Bluebird Citybus were made to Middletown, Connecticut in October, 1980.

3.1.2 Collins Step-Lift Operating Description

The Collins lift is functionally similar to other earlier passive lifts which are stowed as two steps. In use, the steps are unfolded to form a platform, and the platform then travels vertically from floor level to ground level. On the Collins lift, the platform is formed by the lower step and its extension, plus the second step. The end gate/entrance ramp is formed from the lower step riser. In forming the platform, the second step moves outward and down to a stop in front of the lower step. At the same time, the lower riser, which is hinged to the second step, unfolds to a flat position. Figure 3.1-1 shows the operating principles. The Step-Lift has pressure-sensitive mats on the two platform segments (both step treads), but not on the ramp segment, to prevent the platform from being folded with someone on it.

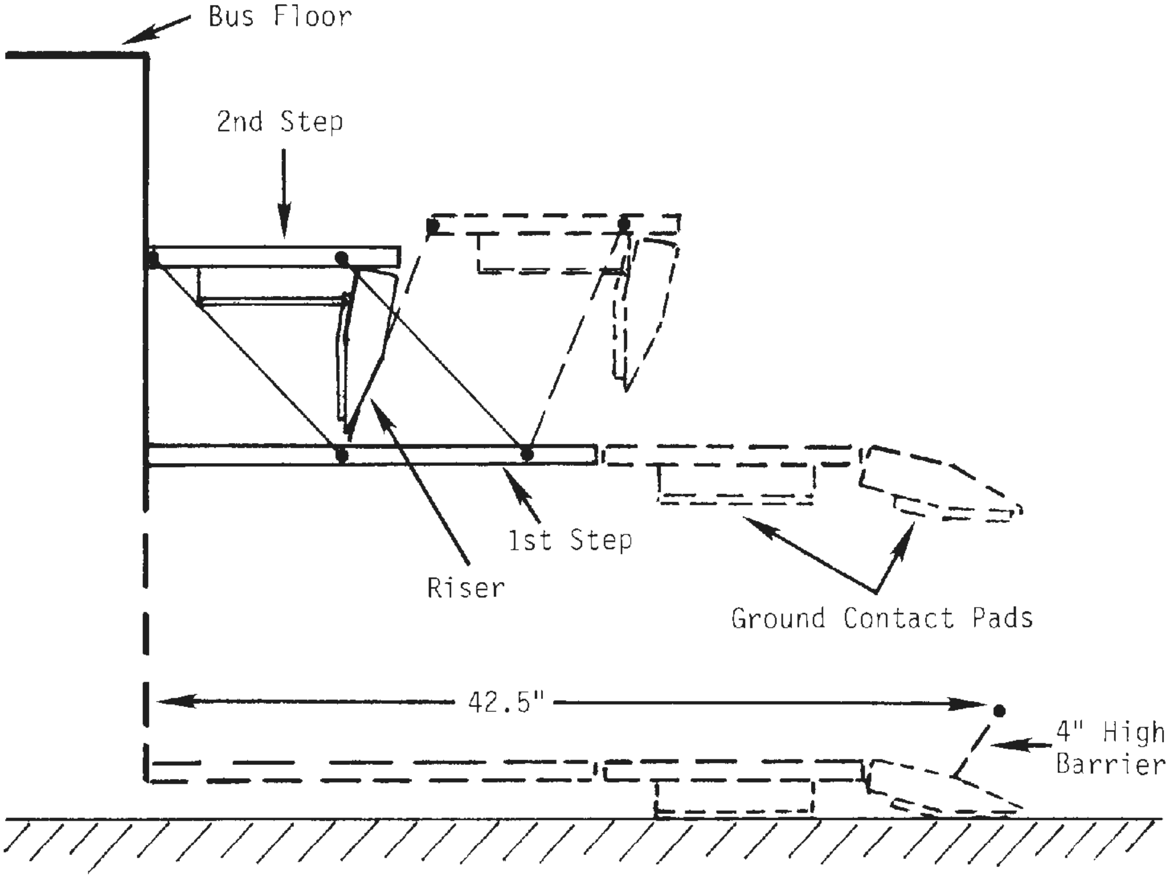

FIGURE 3.1-1: OPERATING PRINCIPLES OF THE COLLINS STEP-LIFT

The downward travel of the lift is stopped when one of the ground sensors contacts the ground. Two mechanical/microswitch sensors are used on the sides of the platform near the front; there are two pneumatic tube sensors, one on the underside of the front of the platform and one on the end of the barrier. As with other lifts of similar design, if some portion of the lift other than a ground sensor contacts the ground first, the lift will attempt to jack the vehicle. On the Collins lift, this action is limited by a pressure switch which senses the rise in hydraulic pressure and stops the pump. Figure 3.1-2 shows the overall linkage arrangement and associated control panel.

The Collins controls are somewhat different from those of other passive lifts. They can be best described as objective-oriented rather than the function-oriented controls of other lifts. The six push buttons on the Collins lift control panel are grouped under "STEP" and "PLATFORM" headings, and their associated actions are:

STEP

- o Raise, and
- o Lower. These two buttons raise and lower the steps as a unit, in effect performing a function similar to that of a kneeling bus. With this approach, an ambulatory person can be raised from ground level to floor level, and has only one full-height tread to climb.

PLATFORM

- o Up. The platform is brought to floor level from any starting position, i.e. from step or from a low platform position.
- o Down. The platform is brought to ground level from any position, i.e. steps or raised platform as before.
- o Release Barrier. The barrier is lowered if the platform is at ground level.
- o Stow. The platform (or steps) is stowed from any location (raised or lowered) as steps at the proper height (unlike other lift controls).

Note that not all functions are paired with the exact opposite function; for example, there is no raise barrier function. The barrier is automatically raised before the platform can lift from the ground. Also, the stow function has two alternative opposites: platform up, or platform down. Either of these two functions first erects the platform if the lift is in the step configuration, and

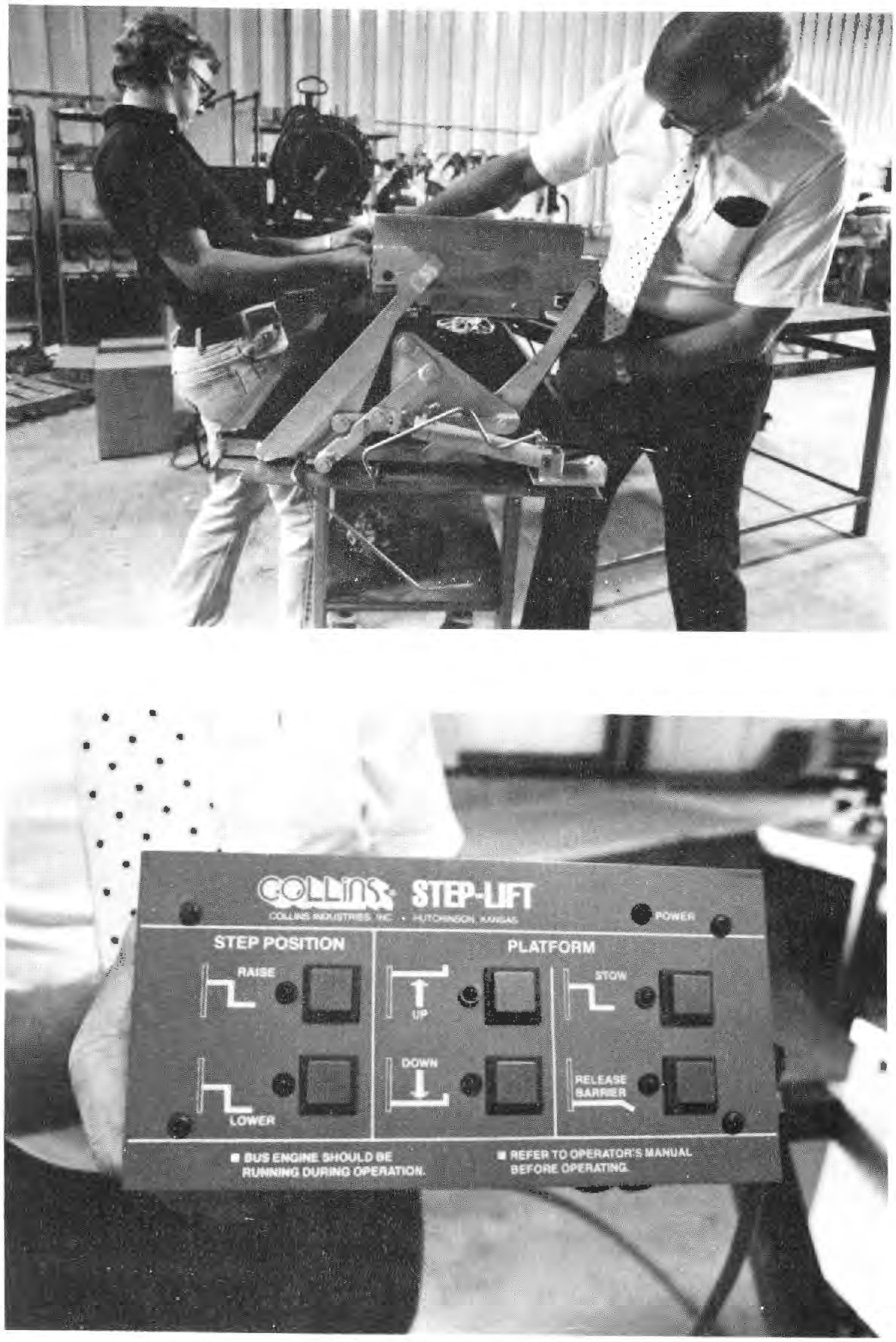

FIGURE 3.1-2: LINKAGE AND CONTROL PANEL OF COLLINS LIFT

then brings the platform to the floor level or to the ground respectively depending on whether a passenger is alighting or boarding. In summary, the sequences proceed as follows:

BOARDING

- o Down. Platform erects with barrier down and descends to ground level, passenger then moves onto platform.
- o Up. Barrier comes up and platform ascends to floor level, passenger moves into vehicle.
- o Stow. Platform descends to proper level and folds to steps.

ALIGHTING

- o Up. Platform erects with barrier up and ascends to floor level, passenger moves onto platform.
- o Down. Platform descends to ground level, but barrier does not release.
- o Release Barrier.
- o Stow. Platform ascends to proper level and folds to steps.

In all cases, the control button must be held for the action to continue.

Disregarding the two step functions, which most other lifts do not have, the Collins lift has only four controls for an operator to learn. Instead of remembering a sequence of actions, the operator of a Collins lift can operate the lift almost intuitively from the control descriptions. The lift actions are actually the same or equivalent to the actions of other elevator type lifts, but the sequence of actions is controlled by a microprocessor. The logic of the microprocessor simply integrates all of the actions necessary to achieve the state indicated by pressing one of four buttons.

In addition to the basic control functions, the microprocessor provides a self-test function for the lift cycle. Once initiated, the test proceeds automatically through a simulated boarding cycle, pausing at the platform down position until the pneumatic sensors on the platform and barrier are pressed manually. After completing the sequence and returning to the step configuration, the test cycle is turned off by pressing the mat switch. The test procedure also incorporates diagnostic indications for various failure modes using a small light adjacent to each function button on the control panel. The four platform-associated lights are employed to provide 15 binary-coded indications of 16 switch failures. Figure 3.1-3 presents the Collins test procedure instruction and error codes for 15 various switch failures. The extra failure indications occurs at binary 13 (on/on/off/on) in which two possible failures are indicated by one message. (The binary count begins with 0, not 1; "on" is taken as the digit 1.)

3.1.3 Development and Modification History

The lift control system described was not available for initial production buses and has been retrofitted in many fleets over the Summer of 1981. Originally, the control box had a four position toggle switch to provide the four functions required of the platform mode namely: up, down, barrier down, and stow.

There has been a campaign by Collins to change the floor, stow, and lower switches and a heavier duty locking system has been introduced.

The lift is now produced in two widths identified by separate model numbers. The S-4210 has a 41.25" clear platform width in a 64.25" module and the S-3010 has a 29.25" clear platform width in a 52.25" module. This latter model allows the use of a more regular size rear door with a 35" clear opening.

3.1.4 Problems Reported

The primary problem with the Collins Step-Lift, based on field reports, has been drifting of the lifts in service.* Other problems have concerned safety barrier operation, the control box, and some broken hydraulic lines. Due to problems associated with the control box, one operator is replacing the Collins unit with an in-house, multi-step toggle switch arrangement.

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* The problem of drifting has been common to several lift designs. The term refers to the tendency of the lift to drift the fully stowed position to a partially deployed position.

COLLINS STEP-LIFT

SELF-TEST OPERATING PROCEDURE

1) Lift should be in the "STOW" position initially before proceeding (see Step 7).

2) Place "TEST/RUN" switches in the "TEST" position by pushing both switches with a ballpoint pen.

3) Press the "STEP UP" button to begin the test sequence. The "STEP UP" light should come on, and the lift will automatically go through the sequence as follows:

    a) Extend platform.

    b) Lower platform until it touches predetermined obstacle.

    c) The "STOW" light will flash until the platform air switch is pressed by the user.

    d) The "UP" light will flash until the barrier air switch is pressed. After pressing the barrier air switch, the "UP" light should turn off. The testing sequence will resume by pressing the "STEP UP" switch.

    e) Raise barrier.

    f) Raise platform to floor level.

    g) Lower platform to "STOW" level.

    h) Lower barrier.

    i) Retract platform.

4) After successfully completing Operations _a_ through _i_, all six lights on the front level will flash on and off. Pressure should then be applied to the step to test the mat switch. The six lights will turn off if this test is successful.

5) Pressing the "STEP UP" switch again will repeat the entire test procedure.

6) _IMPORTANT:_ In case of emergency, to stop the lift sequence at _any time_ during the self-test operation, press the "STOW" button.

7) To operate the self-test mode, the lift must be returned to the "STOW" position by placing the "TEST/RUN" switch in the "RUN" position and then pressing "STOW." Perform Steps 2 and 3 to re-enter to the self-test mode.

FIGURE 3.1-3: SELF-TEST PROCEDURE FOR COLLINS LIFT

If a malfunctioning switch is detected, the front-panel lights will display a code corresponding to the type of problem. Also, the lift will stop immediately to prevent any damage to the system.

The error codes which will be displayed are described below:

Barrier Release	Light Stow	Down	Up	Malfunction
OFF	OFF	OFF	OFF	"IN" SWITCH NOT MADE
OFF	OFF	OFF	ON	STOW LEVEL SWITCH NOT MADE
OFF	OFF	ON	OFF	"OUT" SWITCH NOT MADE
OFF	OFF	ON	ON	"IN" SWITCH STUCK CLOSED
OFF	ON	OFF	OFF	"LOCK" SWITCH NOT MADE
OFF	ON	OFF	ON	"OUT" SWITCH STUCK CLOSED
OFF	ON	ON	OFF	BARRIER UP SWITCH NOT MADE
OFF	ON	ON	ON	BARRIER DOWN SWITCH STUCK CLOSED
ON	OFF	OFF	OFF	STOW LEVEL SWITCH STUCK CLOSED
ON	OFF	OFF	ON	FLOOR LEVEL SWITCH NOT MADE
ON	OFF	ON	OFF	BARRIER DOWN SWITCH NOT MADE
ON	OFF	ON	ON	BARRIER UP SWITCH STUCK CLOSED
ON	ON	OFF	OFF	FLOOR LEVEL SWITCH STUCK CLOSED
ON	ON	OFF	ON	PLATFORM OR BARRIER AIR SWITCH STUCK CLOSED
ON	ON	ON	OFF	"LOCK" SWITCH STUCK CLOSED

FIGURE 3.1-3: SELF-TEST PROCEDURE FOR COLLINS LIFT (continued)

3.2 ENVIRONMENTAL EQUIPMENT CORPORATION

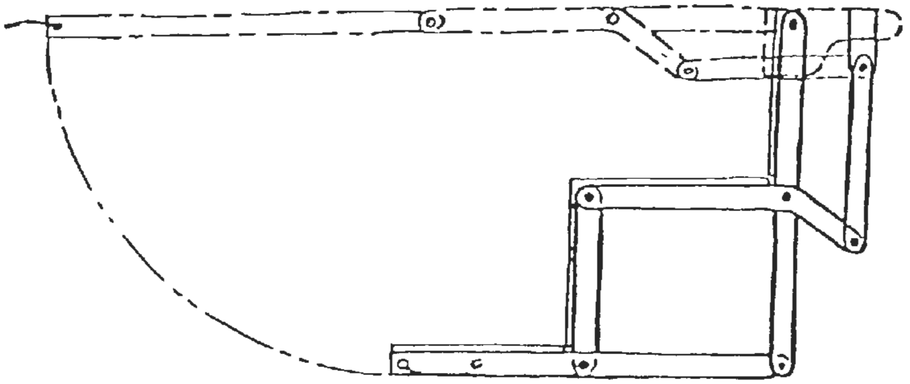
3.2.1 Company Background

Environmental Equipment Corporation (EEC) began business in 1974 as an adapter of vehicles for handicapped drivers. This work led into the development and production of active type personal lifts for private and paratransit vehicles. EEC also developed an auxilary extending step for transit vehicle use. The first EEC passive lift was developed in 1975 and since then EEC has developed three series of lifts designated by the model numbers, 110, 120 and 140 for various installations. Over 2,000 lifts have been manufactured (largely the 120 and 140 models) making EEC the second largest supplier after GMC at the time of the site assessments.

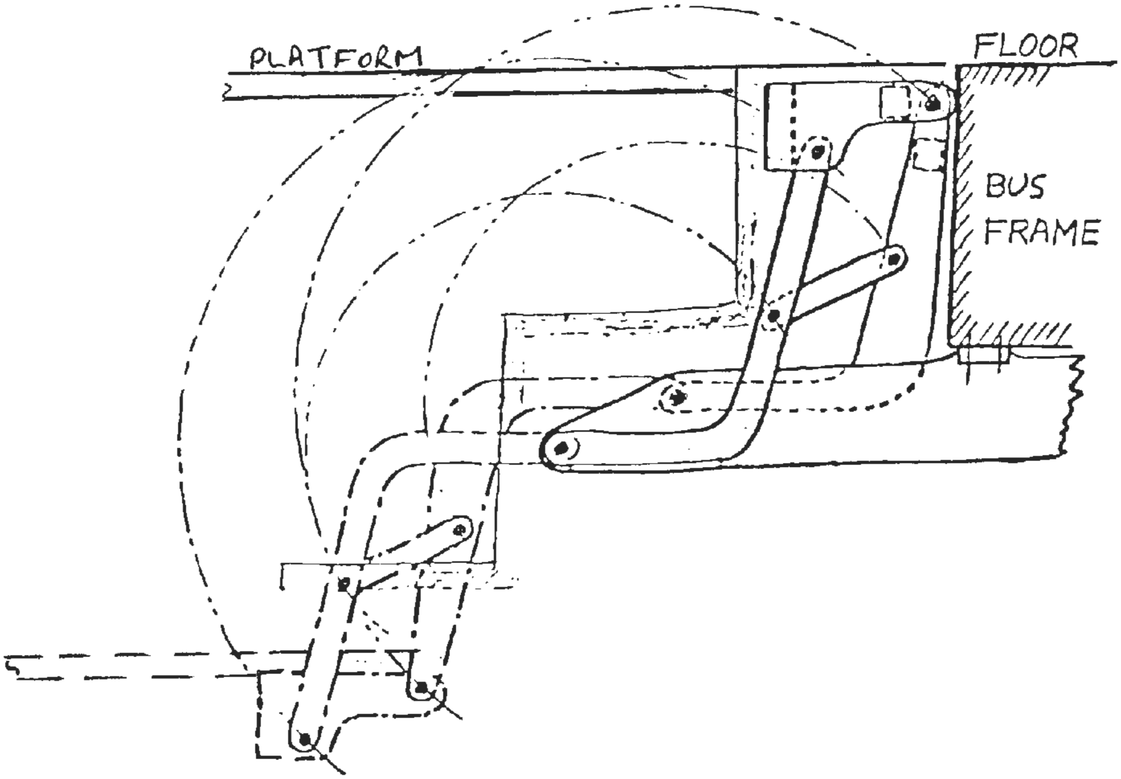
3.2.2 EEC Lift Operating Description

All of the EEC passive lifts work on the same basic geometric principles shown in Figure 3.2-1. The platform is formed from the steps and risers and then deployed in an arcing motion by parallel arms. A level sensor is incorporated into the lift which allows the platform angle to be adjusted to compensate for crowning of the road, bus roll due to an offset load, and droop of the platform under load. Using this system, the platform will stay in a horizontal position. A handrail system is built into the forward side of the lift and includes a fold-down seat for use by ambulatory persons. This is intended to overcome the disadvantage of reduced headroom clearance (the distance between the lift platform and the top of the doorway) caused by the lift's arcing motion. Although all three models use the same basic geometry, they differ in many of their mechanical features and applications.

Model 110. This was the original design intended for high floor coaches and was installed in a number of retrofits including 10 for Denver's RTD in 1977 and 15 (by a subcontractor) for Champaign-Urbana, Illinois in 1979. The lift was deployed by a direct acting hydraulic cylinder installed transversely across the bus as shown in Figure 3.2-2.



PLATFORM ERECTING LINKAGE



PLATFORM DEPLOYMENT LINKAGE

FIGURE 3.2-1: DESIGN PRINCIPLES OF EEC LIFTS

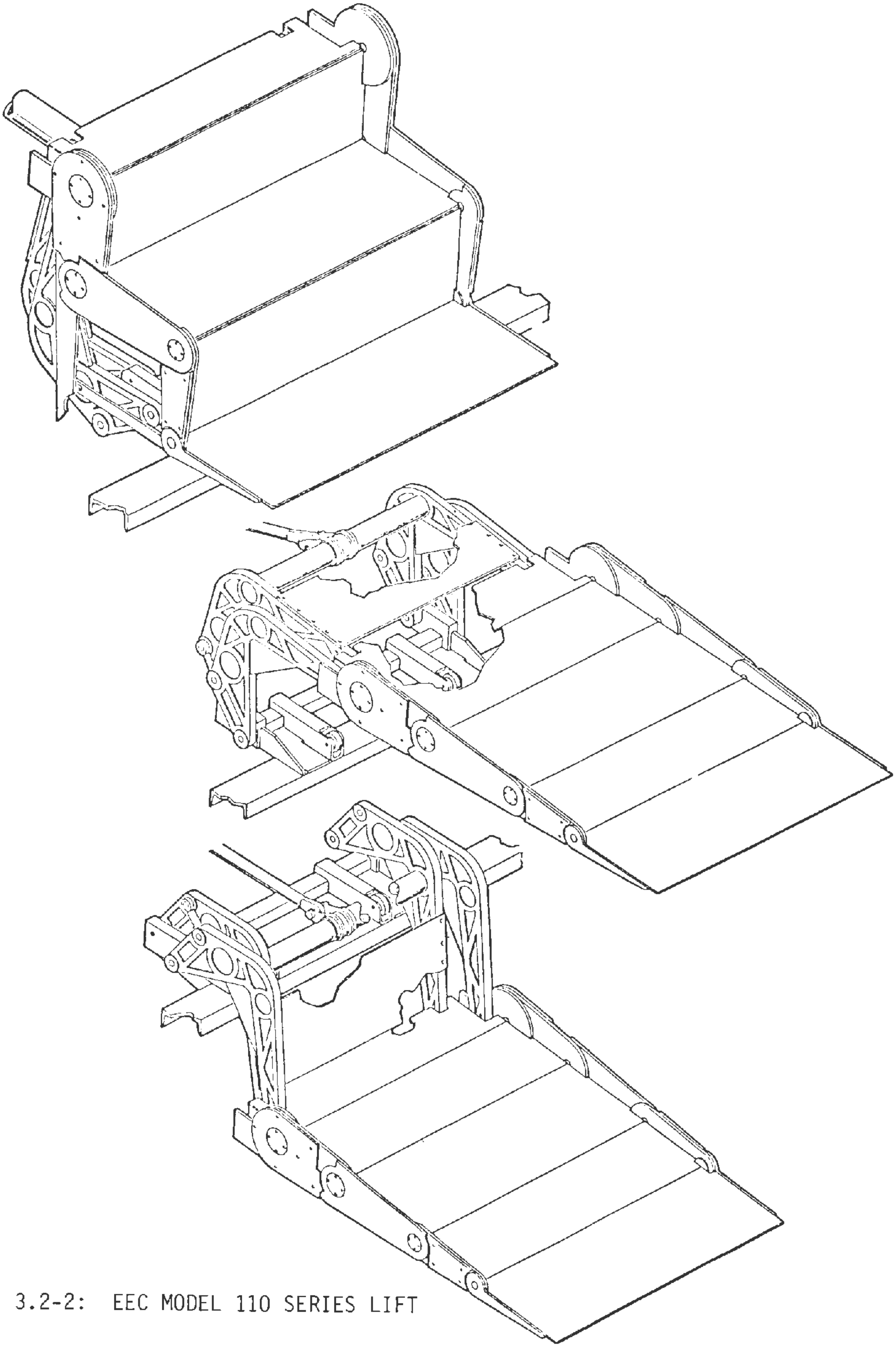


FIGURE 3.2-2: EEC MODEL 110 SERIES LIFT

Model 120. This lift was specifically designed for and tailored to the lower floor and step geometries of the ADB specification buses. Until mid-1981 it was the standard production item for accessible GFC-870 buses and is still available (along with other lifts) as a customer option. The 120 model has evolved through three sub models;

> A Series of lifts which constituted the initial production of 280 units for the State of Connecticut for buses to be operated in Hartford, New Haven, and Stamford.
>
> B Series lift units produced after the A series which incorporated modifications to the electrical system and a revised safety barrier. About 1,500 of the B series lifts were supplied to GFC for their Model 870 bus.

Both the A and B Series deploy the lift through a lever attached to a worm gear reduction box. This in turn was driven by a hydraulic motor through a chain and sprocket drive. For future production EEC planned to use a third series:

> C Series units of the 120 model would substitute a hydraulic rotary actuator for the present deployment drive system. This would be much simpler, lighter, and provide commonality with the later 140 model lifts.

EEC has noted that the design of the 120 series was in part dictated by the requirements of GFC. These design requirements included use of relays and diodes instead of solid state logic circuits and use of a secondary hydraulic pump in addition to the powersteering pump take-off. It is worth noting that GFC was probably influenced in the development of design requirements by their previous experience in St. Louis where both of these design areas gave considerable in-field problems.

Model 140. Designed as a module for original or retrofit installation in high floor buses the 140 model is the standard unit on production units of GMC (Canada) "new look" buses. About 500 Model 140 units have been supplied for original equipment installation, and approximately 250 units have been supplied to various properties and bodybuilders for retrofit installations. The Model 140 uses an EEC designed and assembled rotary hydraulic actuator to deploy the lift platform. The actuator is operated by a self-contained electro-hydraulic motor-pump unit which is generally mounted on a slide-out tray (similar to a battery installation) installed on the curbside of the bus immediately behind the front wheelhousing. In addition to the steps and risers, the lift (as in the 120 B Series) uses a small portion of the interior floor surface in the vestibule for the inboard end of the platform. This is designed to rise up to about a 70 degree angle and form an inner barrier when the platform is not at bus floor height. This feature protects against wheelchair run-off and shields the lift passenger from the mechanism which is exposed when the lift is deployed. The 140 control system includes the use of an extra switch called the Step-Bypass switch which is mounted separately from the control panel and generally to the left of the driver. This switch must be engaged simultaneously with the Barrier-Down switch to allow the step mode or barrier down functions to occur.

3.2.3 Development and Modification History

The model series outlined above represents the major EEC lift developments. A number of modifications made by properties were observed in the field. These included improved undershielding and sealing (Grand Rapids), a modified outer safety barrier (Champaign-Urbana) on their 120B lifts, and stops to relieve the wheelchair loads on the outer platform panels (RTD Denver) on their 140 series of lifts. RTD also reset the platform level sensors from a ± 2 1/2° setting to a - zero to 5° range to avoid negative platform slopes.

3.2.4 Problems Reported

The problems reported by the operators for the 120B and 140 series of lifts are summarized below. In many cases, they are concerned with adjustment and quality control items rather than major technical or mechanical problem areas.

3.2.4.1 Series 120B Lifts - Two items were reported which have also been the subject of factory modification programs. These are redesigned seals on the safety barrier cylinder and modified pins with an increased diameter housing (washers were used in the field) to prevent the cylinder from contacting the ground. The level sensor was also reported to be troublesome. One operator instituted a comprehensive maintenance program to free-up and lubricate the level sensor.

Failures of expensive items included the pump ($1,700), control box ($1,525), and control valves ($236). Fatigue failures of the handrails at the point where they are welded to the baseplate were also reported, along with wiring failures due to bad routing and hose failures due to excessive hydraulic pressure.

Sensitivity to cold weather operation (use of hydraulic fluid, not oil, is recommended) and corrosion at different metal to metal interfaces was also noted.

3.2.4.2 Series 140 Lift - Experience with this lift is more limited than with the earlier models. Major problems reported included early failures of the bonding in a batch of rotary actuators which caused the vane to separate from the shaft and immobilize the lift, wiring failures due to harnesses being installed too tight in order to present a neat tidy appearance (at the customers request), and problems with leveling the erected platform. This is not a continuous function on the 140 series as it is on the 120 series. Consequently, the driver must maintain the platform switch in the on position until the platform has leveled. Early release of the control will leave the platform in a plane position, but at a negative angle resulting in a potentially hazardous condition.

3.3 GENERAL MOTORS CORPORATION

3.3.1 Company Background

General Motors Corporation (GMC) is unique among lift manufacturers for two reasons. First, it is the only major manufacturer of transit buses that makes its own lift. Second, it installs the lift in the rear door of the RTS series of buses. To date, GMC has shown no interest in supplying their lift to other bus builders or for use in retrofit programs. GMC's first lifts were installed on buses delivered in 1978. Since GMC dominates the market for transit buses, their lifts constitute the major share of lifts in service. At the time of Phase I, completion GMC had delivered approximately 2200 lift-equipped buses which represented 43% of the total number of lifts in service. Since that time, the number of GMC lift-equipped buses has grown substantially but their proportion of the market has probably not changed very much.

3.3.2 GMC Lift Operating Description

Figure 3.3-1 shows the general operating principles of the GMC lift. All the treads and risers are used in the formation of the platform. The safety barrier is not formed from the steps, but is a separate device stored under the lower step when the lift is in the stowed position. The overall platform operation is provided by hydraulic pressure from the power steering system. The GMC lift differs from other lift designs by using pneumatic power for the locking pins which stop lift drifting from the stowed position, and also to actuate the safety barrier.

The GMC lift is largely of stainless steel construction which, according to the manufacturer, was adopted in anticipation of corrosion problems in urban areas. The rear door stepwell has, unfortunately, been reportedly used as a public latrine by both passengers and bus drivers on late night routes in undesirable areas.

A unique feature of the recommended GMC lift operating procedure is use of the kneeling feature which tilts the bus towards the curb. The objective is to ensure that the sensitive edge is the first item to make ground contact. However, the platform gradient produced makes it more difficult for some users to board the lift.

3.3.3 Development and Modification History

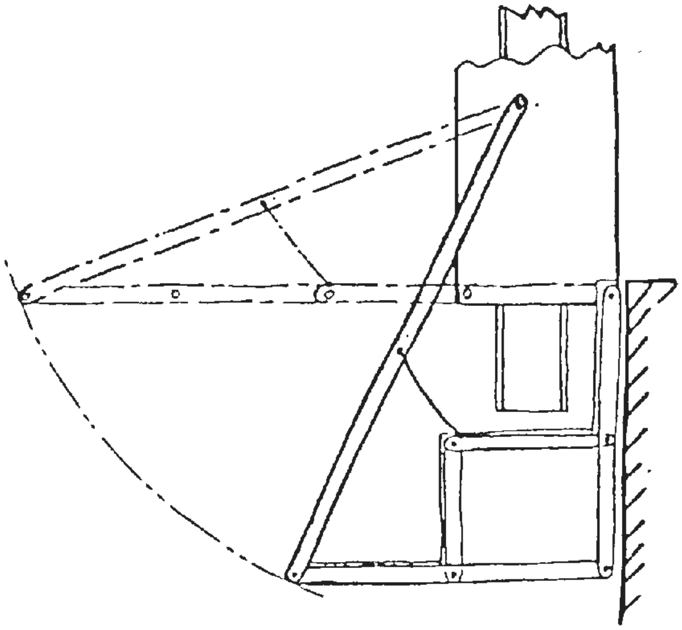
The production lifts at GMC have incorporated a number of improvements on a running change basis in the light of operational experience including:

1) Providing locking pins with a hardened, plated surface to counter corrosion and sticking problems with the locks.

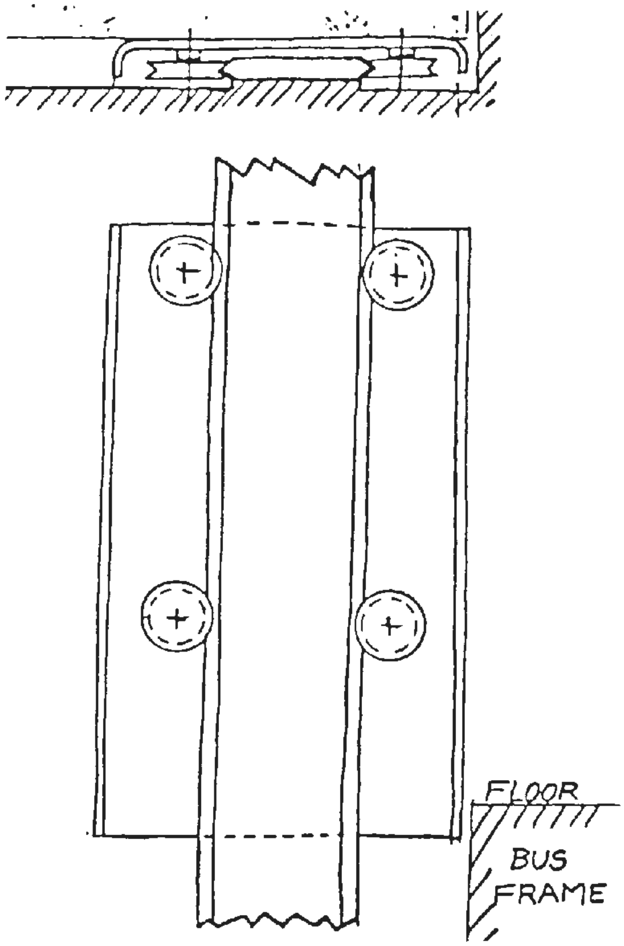
2) Development of an undertray to provide protection from road spray, mud, snow, ice, and salt (Figure 3.3-2).

3) Replacing push connectors with a screw type on low voltage microswitch circuits to overcome corrosion problems.

4) Installation of an elongated hole and sensing microswitch on the platform erecting arms. This was designed to shut off power to the lift and prevent it from jacking the bus if the ground contact sensitive strip fails to stop the lift.



STEP TO PLATFORM CONVERSION



GUIDE AND ROLLERS FOR VERTICAL MOTION

FIGURE 3.3-1: OPERATING PRINCIPLES OF THE GMC LIFT

5) Modifying the circuitry to remove pressure from the safety barrier system in the stowed position which would cause it to drift out (Figure 3.3-3). At the same time, an extra spring was incorporated in the underside closure doors then acts to mechanically restrain the safety barrier.

6) Providing a revised locking pin configuration during 1981 production to overcome persistent sticking problems with the locks. The system incorporated improved alignment and wedge action.

Some of the operators of early model GMC lifts had anticipated GMC modification programs. To overcome problems with moist exhaust air and spray freezing in the ports of the pneumatic actuators, exhaust pipes had been added to duct the air away. The Detroit Department of Transportation (DDOT) installed its own full width undershield (Figure 3.3-4) to protect the exposed mechanisms. DDOT had also produced its own numbered operating sequence for the lift and installed a new decal with it on the control box (Figure 3.3-5). They felt their system was simpler to understand for those drivers using lift-equipped buses on an occasional basis.

3.3.4 Problems Reported

Reported problems identified with the GMC lift included the need to frequently and free-up and lubricate the locking pins and repairs related to the lift having jacked up the bus. Jacking repairs included hydraulic cylinders and recurrent breakages of special shoulder bolts; a cheaper replacement in the form of a regular bolt and washers has been found to reduce costs. The jacking related failures appeared to be due to either a failure to kneel the bus as recommended or to failures in components of the sensing systems such as the microswitches. A number of control box ($754 each) failures have also been reported.

3.4 LIFT-U, INC.

3.4.1 Company Background

Lift-U, Inc. is unique among the lift suppliers examined in this project because it is primarily a sales and service organization with its product manufactured by a subcontractor. The mechanical concept of the lift was developed by Ed Hall, an engineer working at METRO-Seattle. A prototype lift was installed

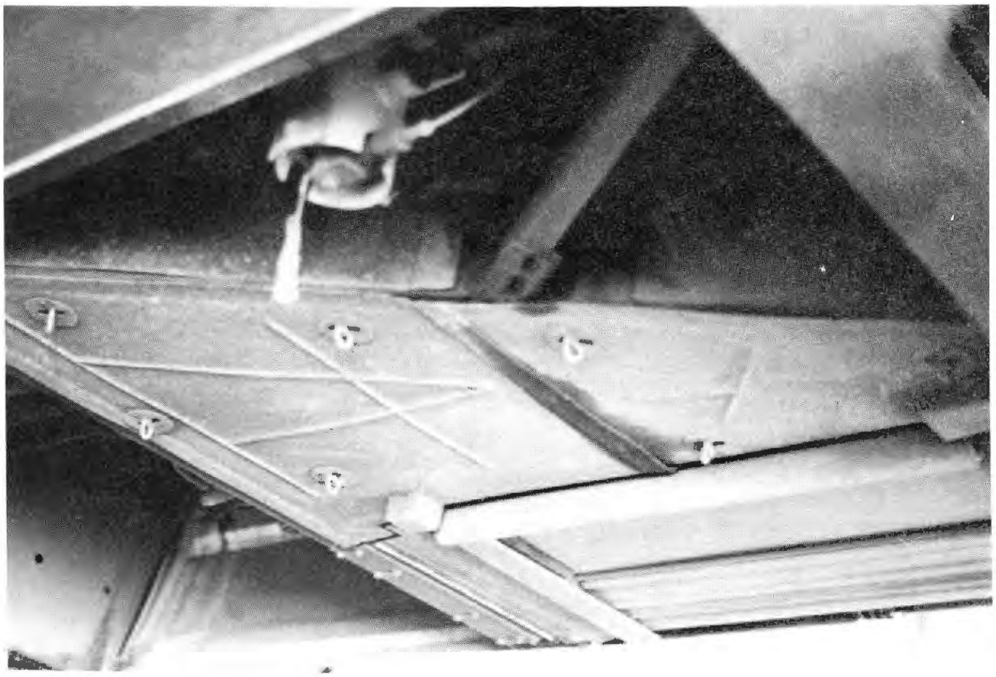


FIGURE 3.3-2: GMC LIFT UNDERSHIELD LOOKING TOWARDS LIFT, FORWARDS IS TO THE LEFT

FIGURE 3.3-3: DRIFTING SAFETY BARRIER ON GMC LIFT

FIGURE 3.3-4: DDOT LIFT UNDERSHIELD, FORWARDS IS TO THE RIGHT

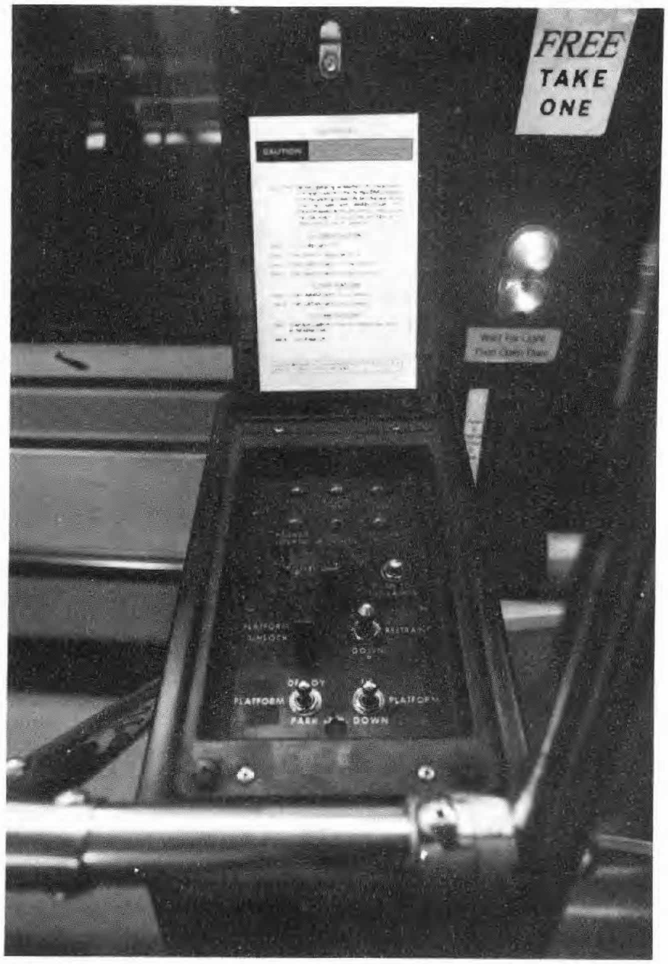


FIGURE 3.3-5: DDOT DECAL AND NUMBERED CONTROL PANEL

on a GM bus used by METRO for service to a handicapped community housing project. At that time, METRO was seeking a lift to install in its newly ordered Flyer buses. They conducted an evaluation of other existing lifts and decided that the Lift-U concept was superior to them all. Ed Hall was referred to a local law firm having a well established legal practice with widespread commercial contacts in the Northwest and as a result, the firm of Lift-U, Inc. was incorporated. Lift-U became the owner of the patents and responsible for marketing the lift. Manufacture of the lifts was contracted with Hogan Engineering of Stockton, California. The original 143 lifts for METRO's Flyers and 89 lifts for retrofit into trackless trolleys were produced by Hogan. Initial delays in payment by METRO for lifts, until the bus installations were formally accepted, caused strained relations between Hogan and Lift-U, and led to a negotiated transfer of production to Transco Northwest, Inc. a diversified engineering company in Portland, Oregon. This new production arrangement had some initial problems with quality control, but a good working relationship has been developed. Lift-U has expanded its staff to include sales and service representatives and quality control inspectors as an independent check upon its manufacturer's operation.

The original customer for Lift-U was Flyer Industries which required nearly 400 units for vehicle deliveries to Seattle, WA; San Mateo County and Torrance, CA. Since then, Lift-U has been retrofitted into a number of vehicles for various properties including GMC (Canada) for Eugene, OR; the MBTA in Boston, MA; Flxible "new look" for WMATA and St. Louis; AMG for MUNI; AMG trackless trolleys in Seattle; and Scania buses in Norwalk, CT. The original equipment users have expanded to include the Gillig Phantom, and Flxible's 870 and METRO series. A new lift was produced in 1981 which was specifically tailored to fit the wide doors of MAN's articulated buses.

3.4.2 Lift-U Operating Description

The general operating principles of the Lift-U are shown in Figure 3.4-1. A one piece platform, which together with the safety barrier also forms the first step tread, is deployed along tracks and then raised and lowered between ground and floor levels by parallel arms on both sides of the platform.

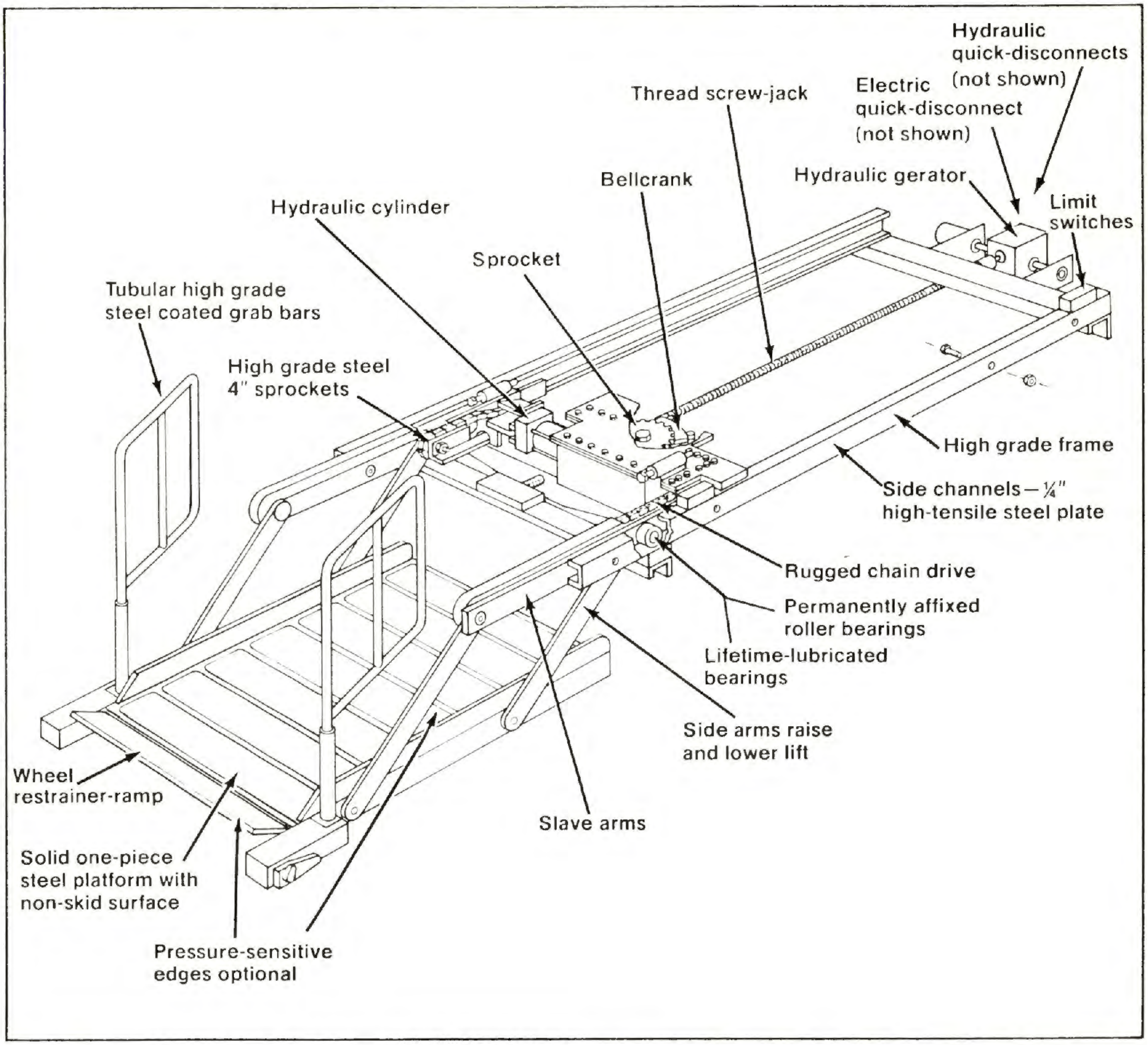


FIGURE 3.4-1: LIFT-U MARK 1 GEOMETRY AND OPERATING PRINCIPLES

3.4.3 Development and Modification History

There are three main variants of the Lift-U which reflect both development experience and the needs of specific installations.

Mark 1. This lift, shown in Figure 3.4-1, is the original design supplied to Flyer Industries for their initial orders of accessible buses for Seattle, Washington; San Mateo County and Torrance, California. It features a platform deployed by a screw mounted under the platform (Figure 3.4-2), and raised and lowered by a single hydraulic cylinder acting on a bellcrank, sprocket, and chain system. A single piece safety gate is used. Hydraulic power is supplied from the power steering system except in the case of the AMG trackless trolleys which have a pneumatic power steering system. For these vehicles, a separate motor/pump powerpack is used. A retrofit of the Mark 1 has been proposed whereby the screw position would be reversed to be above the platform as in later versions. San Mateo County has expressed interest in such a retrofit.

Mark 2. This basic model has been used on all orders for regular transit buses after the Flyer bus installations which used the Mark 1. The major changes incorporated are:

1) Reversal of the platform deployment drive screw to be above rather than under the platform in the stowed position.

2) Use of individual lifting cylinders on each side of the platform to raise and lower it.

3) Increasing the size of the safety barrier and making it two pieces rather than one. This gives a better ramp angle for access and increased height and angle as a safety barrier.

4) Changing the motion of the trigger mechanism for the safety barrier from vertical rotation to horizontal sliding to avoid sticking problems. In addition, the latest models with suffixes F (Flxible 870) and G (Gillig Phantom) incorporate another change.

5) A raised panel at the inboard end to provide a safety barrier at each end of the platform.

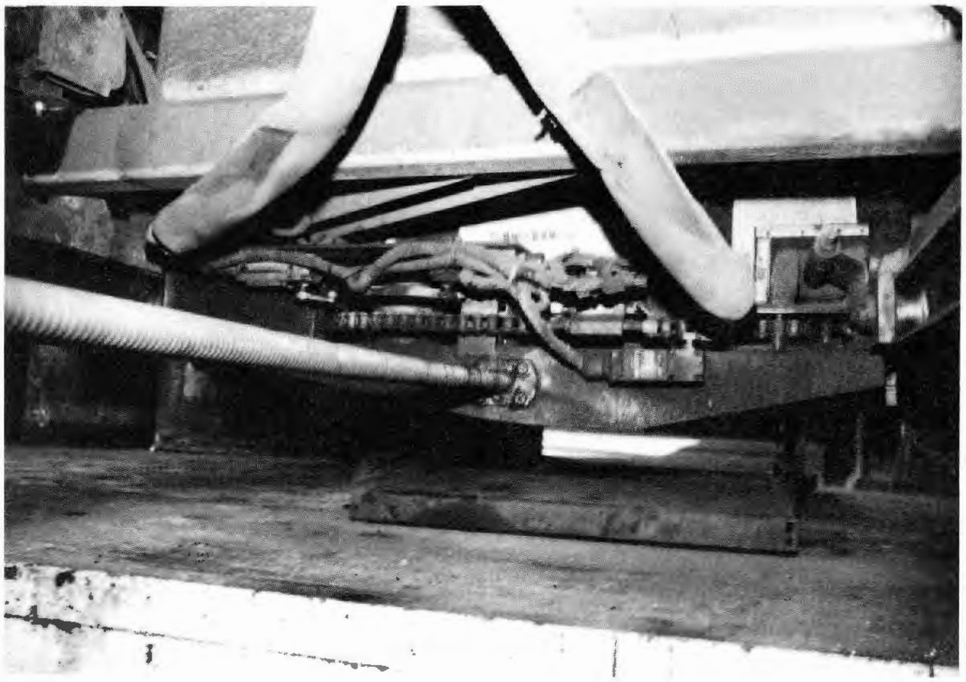


FIGURE 3.4-2: UNDERSIDE VIEW OF DEPLOYED LIFT-U MARK 1 AT METRO-SEATTLE

Mark 3. This is the designation of the lift developed for installation in the MAN articulated bus. The major changes incorporated are:

1) Increased platform width to fully utilize the 44" clear opening provided.
2) Use of sliding blocks instead of rollers in the tracks to improve self-cleaning capability.
3) A bevel gear drive to pinions moving in racks on each side of the platform in place of the screw.

In addition to the changes reflected above, a number of other modifications have been made to the lift systems. Surge pressure experienced when a diverter valve operated to direct hydraulic power to the lift was cured with a relief valve installation. Originally the safety barrier was held up with hydraulic pressure on the operating cylinder and any leakage would allow the barrier to become "soft" and be overridden by hard contact pressure. METRO developed an overcenter linkage which was incorporated into the design to overcome this problem. A number of chain failures were experienced with the original lifts and Lift-U had an independent testing organization (Pittsburgh Laboratories) conduct an investigation. It was found that while the nominal strength of the chain used was 8,000 lb. production chains varied greatly from this (as low as 4,000 lb.) and that 8,000 lb. only represented an average production figure. Lift-U conducted a field campaign and replaced the chains with those from a manufacturer who would guarantee the 8,000 lb. as a minimum. Subsequent lifts supplied by Lift-U have chains with design strengths of 22,000 lb.

3.4.4 Problems Reported

The major problems reported with Lift-U include wear on the screw drive nut and hydraulic leaks from the seals in the cylinders and hydraulic motor. The exposed screw (on the underside of the platform) on the early lifts was also subject to some wear and damage.

The retrofitted installations in the GMC (Canada) "new look" buses required constant supervision to maintain the track alignments. This was attributed by the operator to the relatively flexible structure (aluminum monocoque) into which it was mounted. The high degree of use by this operator might also be a factor.

3.5 TRANSILIFT EQUIPMENT LTD.

3.5.1 Company Background

Transilift Equipment Ltd. is a Canadian Company headquartered in Calgary, Alberta. Because of "buy American" provisions and problems involved with acceptance of a lift installation by the California Highway Patrol, the company did not establish a permanent place in the United States market. Indications are that, as a result of the relaxation of the USDOT regulations on accessibility, Transilift has withdrawn from the market. Apart from six retrofits to individual transit buses, the Transilift has only been supplied as original equipment on Orion buses manufactured by Ontario Bus Industries. Twelve of these were supplied to U.S. operators, including the largest fleet of nine buses in Port Huron, Michigan.

3.5.2 Transilift Operating Description

The Transilift configuration is very similar to that for the GMC lift but with significant differences in operation. The platform lowers under gravity and is raised hydraulically by two cylinders acting through chains over sprockets. The platform is erected by a second set of hydraulic cylinders on each side of the platform with built-in handrails forming the fixed length arms of this linkage. The platform segments are formed from 1/4" steel plate to provide a thin platform. Hydraulic power is supplied to the platform and vertical movement systems by two independent pump/motor systems. Mechanical locks are provided for the hydraulic systems. The unpowered lowering of the platform allows it to adjust to uneven ground conditions of up to five degrees of tilt at either side of the platform.

3.5.3 Development and Modification History

Mechanically the lift is very simple and no major developments have been necessary. To improve its suitability for use by the ambulatory, the latest production lifts featured a revised handrail configuration. The handrail is tubular with a raised upper portion that provides for a more convenient handgrip for anyone standing on the lift platform.

3.5.4 Problems Reported

No significant problems were reported with the lift. Retrofitted installations in GMC "new look" buses have been criticized for leakage, drafts, and noise around the modified doorway. The normal door path must be modified so that the door remains outside of the bus in the open position in order to allow a lift platform of adequate width. This has made it difficult to obtain a rigid, draft-free fit in the closed position. The height and size of the front tower has been criticized by some drivers for obscuring vision and therefore presenting a safety hazard.

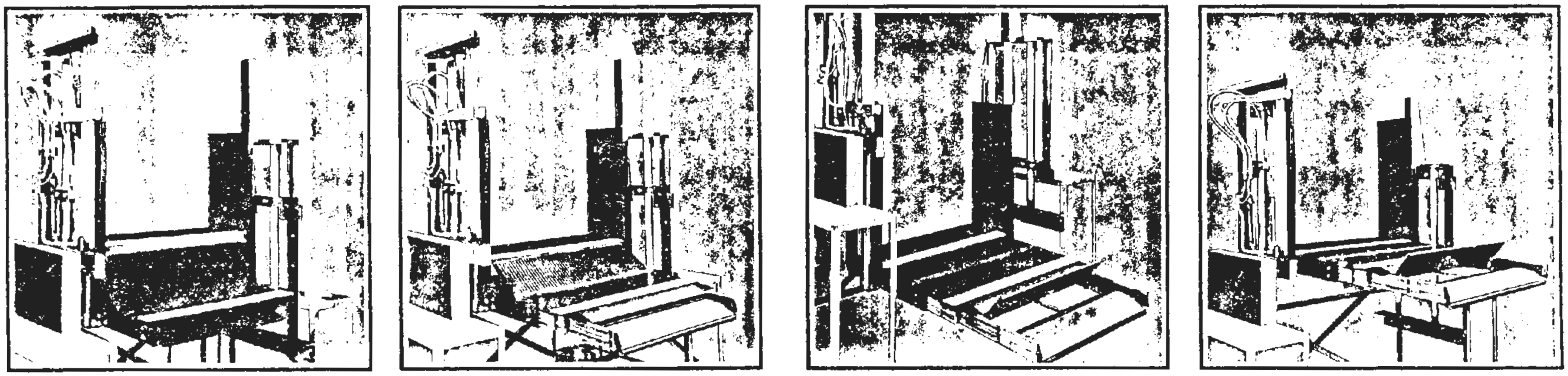
3.6 TRANSPORTATION DESIGN AND TECHNOLOGY, INC.

3.6.1 Company Background

Transportation Design and Technology, Inc. (TDT) was the first company to market a passive lift using patented designs (issued by the U.S. and Canadian Patent Offices). The first lifts were produced in 1974 and were used in a number of smaller vehicles, such as the Transcoach, for demand responsive services and in retrofits of GMC "new look" buses for specialized fixed route services in San Diego and Atlanta. TDT lifts were supplied as original equipment on AMG and TMC vehicles until both bus manufacturers withdrew from the marketplace. TDT also supplied components to Flxible for the lifts that were installed in 1977 on the buses for the Bi State Development Agency's pilot program of accessible fixed route service in St. Louis, Missouri. TDT has replaced its original lift with a greatly improved design deliveries of which started in July of 1980. Currently, the lift is offered as an option by Flxible (870 and METRO series), Neoplan, Chance, and Ontario Bus Industries (Orion). TDT has also engineered a retrofit installation of its lift into the front door of sixty-six RTS-2 buses for Santa Clara County, California.

3.6.2 TDT Lift Operating Description

The same basic operating concept is used in the Series 30 and the newer Model G-50 lifts produced by TDT. The platform is formed from an extending tray, the first and second step treads, and the first riser. Unlike other lifts, the second riser is not used. Figures 3.6-1 and 3.6-2 present the early (30) and later (G-50) models of the TDT lift illustrating some significant changes between the two. The



Lift in normal step configuration

Steps unfolding to platform position

Lift at curb or ground position

Lift at floor level

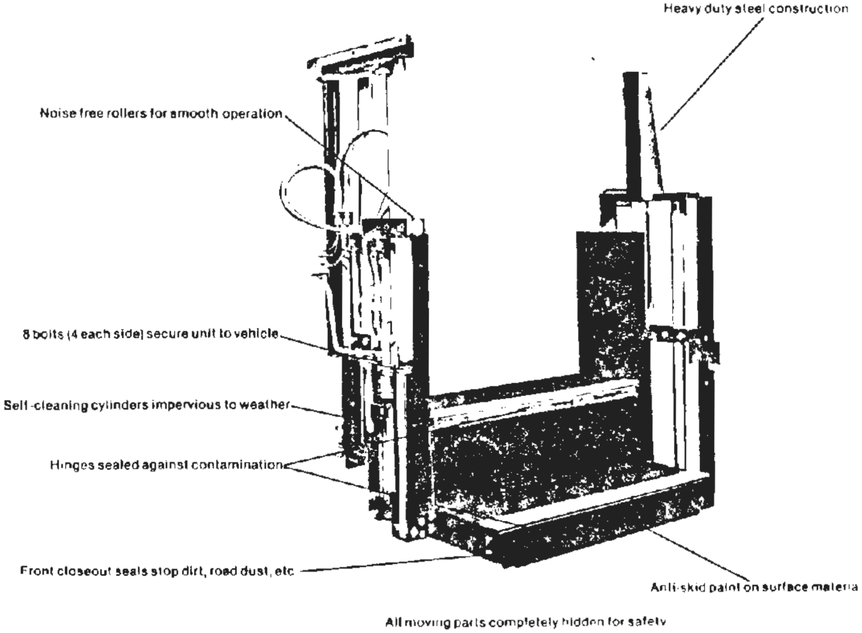


FIGURE 3.6-1: ORIGINAL TDT LIFT CONSTRUCTION AND OPERATING PRINCIPLES

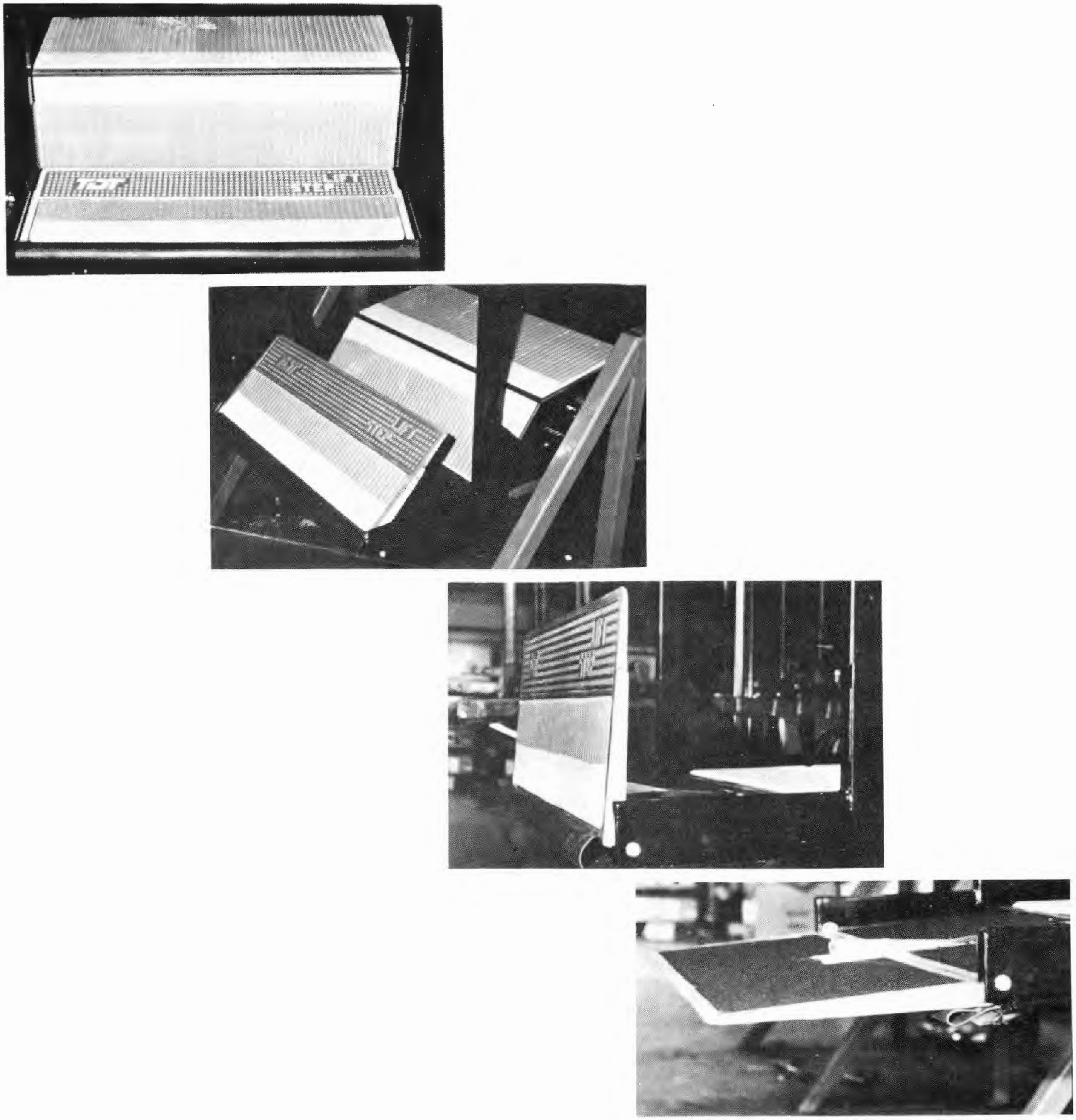


FIGURE 3.6-2: REVISED STEP AND SAFETY BARRIER GEOMETRY
OF TDT G-50 LIFT

safety barrier on the G-50 which is formed from the first step is higher (12") and is placed at the end of the platform. Large diameter rollers are used to support the extending tray instead of the ball bearing tracks used on the Series 30. On the G-50 the lift is raised and lowered by a single hydraulic cylinder at the rear side of the platform. The cylinder acts on a chain running under the lift and up into the forward lift tower to equalize the motion. As a result, the lift towers have been substantially reduced in size. The G-50 lift has been designed as a modular unit for ease of installation.

The two largest TDT lift installations to date have been the retrofit to 81 Gilligs for Santa Clara County and the installation (really a retrofit) of 243 Flxible 870's for three California properties. Of these, 219 are for Santa Clara County, and the others are for Fresno and North San Diego County. The Gillig and Flxible installations differ in two ways. The Gillig is powered off the power steering system while the Flxible uses a motor/pump unit. The G-50 installation uses a sensitive edge and a local contact plate for sensing ground contact. On the Gillig, both circuits must be made to allow the safety barrier to lower. On the Flxible, making either circuit is sufficient.

3.6.3 Development and Modification History

A number of improvements and modifications to the TDT lifts are summarized as follows:

1) The base of the front tower is machined off to a 45 degree chamfer angle to preserve the approach angle on the Flxible 870. This is done at TDT prior to shipping the module.

2) The lift "power on" circuit is now activated by a microswitch which is contacted when the door is fully open. Previously, it was activated as the door started to open which led to cases where the lift jammed in the doors.

3) An extension was added to the contact plate ground sensor to improve contact capabilities.

3.6.4 Problems Reported

The G-50 lifts were still being introduced into service during the site visit periods. Analysis of several months of repair orders indicated that there had been no specific major problems that stood out. The most troublesome areas, apart from door related problems, were safety barrier system repairs and adjustments, adjustment to the anti-drift locks, replacement and repair of sensitive edges, and wiring repairs. The most frequently reported complaint was failure of the safety barrier to lower. This was in part due to mechanical problems but in many cases appeared to be due to failure of the ground sensors to make adequate contact.

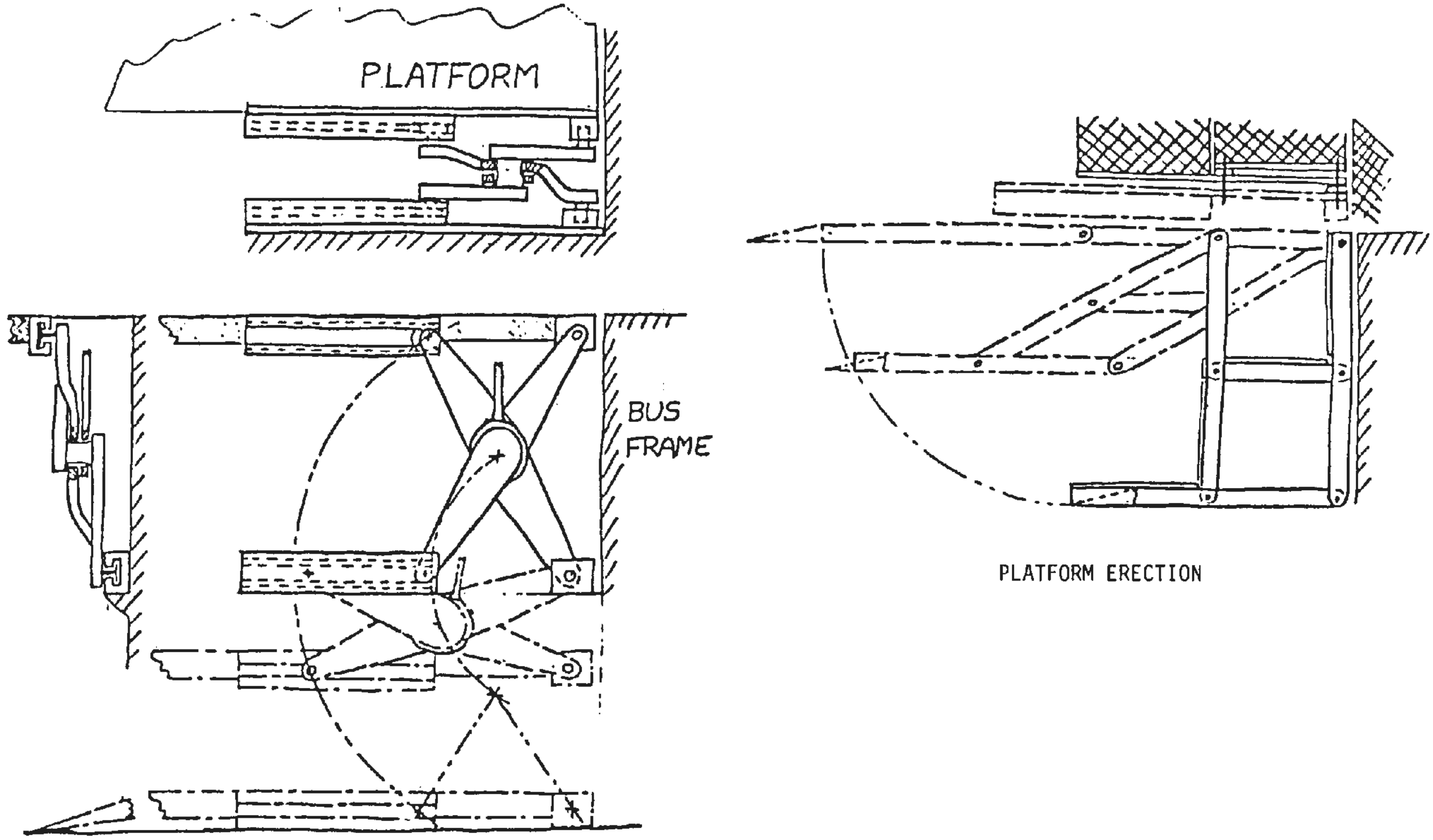
3.7 VAPOR CORPORATION

3.7.1 Company Background

The Vapor Corporation is a major supplier of general equipment to the transit industry. It is well staffed with regional technical representatives and maintains a reputation for product quality. These considerations appear to have been major factors in several transit properties' decisions to purchase the Vapor Travelift. Vapor entered the wheelchair lift market in early 1978, with the Travelift supplied as original equipment on 250 GFC "new look" buses purchased by Milwaukee, Wisconsin and Washington, D.C. The Travelift was also supplied as original equipment on Chance's small, RT-50 bus which has the lift installed in a wide door behind the front wheels. Operators of the Chance RT-50 bus in Austin, Texas and Indianapolis, Indiana - use the vehicles to provide demand responsive service for the elderly and handicapped. This type of service results in intensive use of the wheelchair lift. In 1981, Vapor was scheduled to supply 464 wheelchair lifts as original equipment on Flyer, Neoplan, and Ikarus and MAN articulated buses.

3.7.2 Vapor Travelift Operating Description

In the stowed position, the Vapor Travelift forms the treads and risers of the bottom two steps in the entry. Four hydraulic cylinders, located in the towers on both sides of the platform, control the operation of the lift. One pair of the cylinders controls the extension of the platform. The other pair of cylinders controls the vertical movement of the platform using a scissors mechanism, as shown schematically in Figures 3.7-1 and 3.7-2. The lift has two sensitive edges: the



PLATFORM TRANSLATION

PLATFORM ERECTION

FIGURE 3.7-1: OPERATING PRINCIPLES OF VAPOR TRAVELIFT

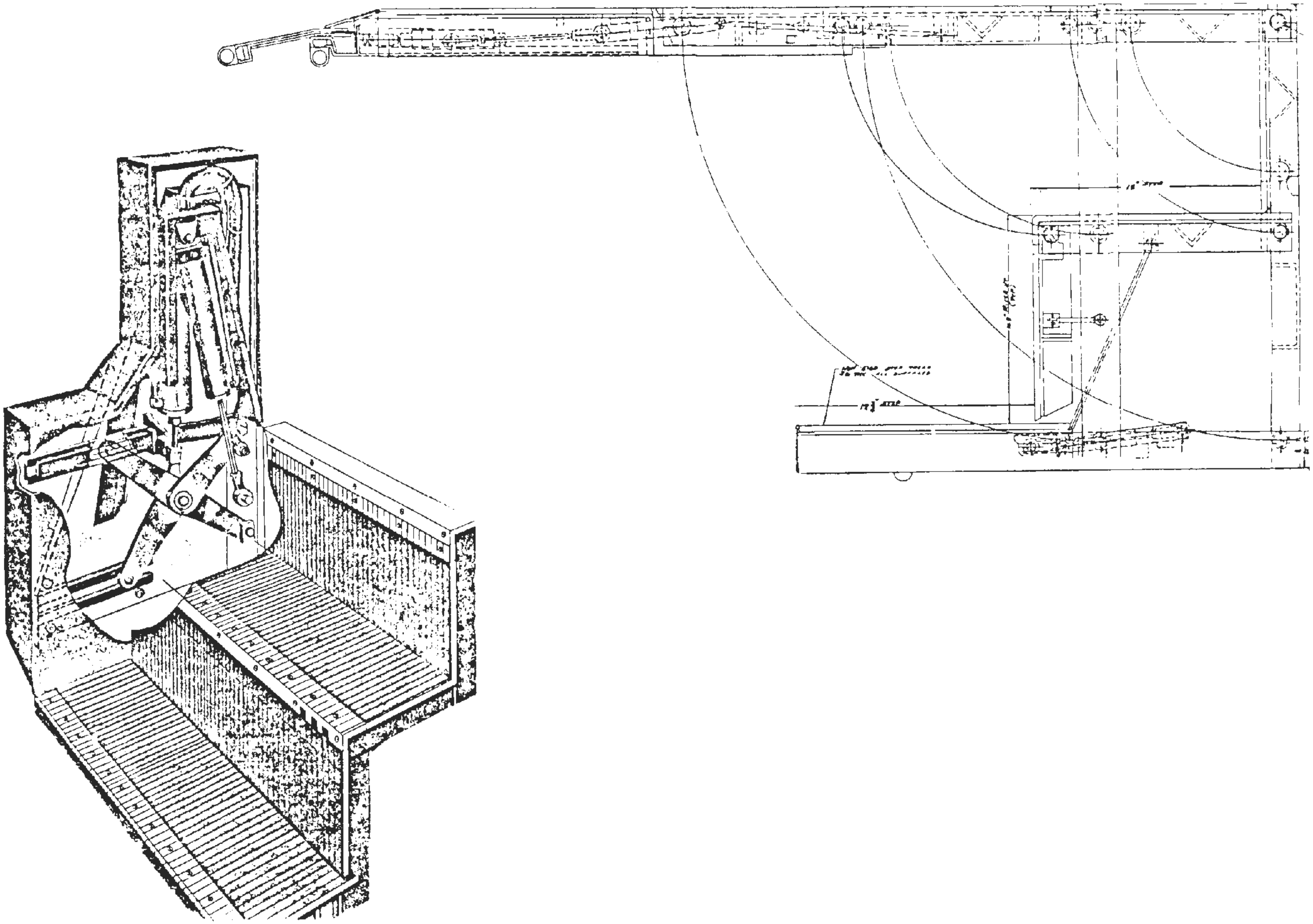


FIGURE 3.7-2: TRAVELIFT TOWER AND PLATFORM INSTALLATIONS

outside edge of the platform and the underside of the platform. The sensor on the outside edge stops the lift if an obstruction is contacted before the platform is fully extended. The second sensor, on the outer edge of the platform underside, stops the descent of the lift if an object is encountered, or when the lift reaches the ground.

The number of control functions for the Vapor lift are similar to those for other lifts. The numerical difference in the number of controls for the Travelift is due to the use of push buttons instead of two-or-three position switches. This gives the appearance of a more complex system. In addition, some of the buttons must be held "on" while others require only momentary contact. The Vapor control console has nine push buttons to control the lift plus a vehicle "kneel" button and a "step out" indicator. The controls and the sequence of operations are arranged as shown in the following diagram (Figure 3.7-3). The four buttons that must be held depressed are shown in bold outline.

3.7.3 Development and Modification History

The modifications incorporated into the lift have centered on the need for improved environmental protection and to avoid lift drifting and bus jacking situations.

Six microswitches are used within the lift mechanism to sense the position of various elements and control the lift motions so that they can occur only in the proper sequence. The first microswitches used by Vapor proved to be very susceptible to dirt accumulation and especially corrosion, particularly with the use of salt directly on the steps of the buses. The microswitch design was improved by increasing the ice scraper around the plunger, providing an integral boot on the plunger, and by changing the anodizing. These modifications solved the local step switch problems, but operators experience shows that the end gate switches can now suffer bent plungers if not installed and adjusted correctly. Although a service bulletin was issued by Vapor prohibiting the use of salt on the steps of the lift, Milwaukee was unable to comply with it. Ice will form on the steps in their winter climate from snow tracked into the bus unless positive measures are taken to prevent ice formation. Because of the repeated opening of the front door, the bus heating system with the lift installed cannot keep the melted snow on the steps from refreezing.

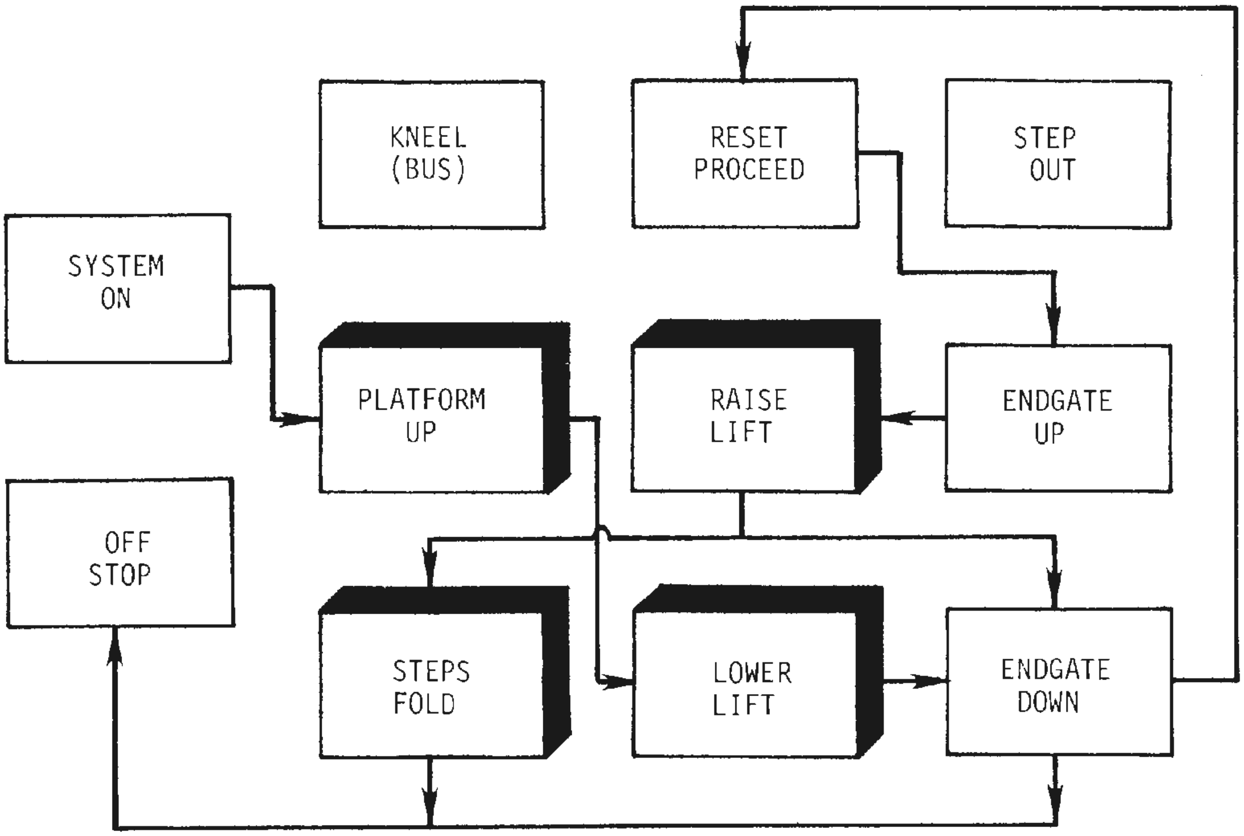


FIGURE 3.7-3: TRAVELIFT CONTROL LAYOUT AND SEQUENCE

The push buttons on the control panels have also been suspectible to dirt ingress. Later versions of the control panel have the buttons sealed under a plastic cover and some operators of early models have fabricated their own covers.

The need to avoid lift drifting was recognized in the original Vapor design; however, the locking mechanism allowed the steps to extend far enough to indicate that the lift was unlocked, which applied the brakes to the bus, even though the condition was safe. Vapor developed an improved lock, which significantly improved the drifting problem. These locks require regular lubrication and maintenance and drifting can still occur if a lock assembly is out of adjustment. The lock pins can be broken if they do not withdraw before the platform deploys.

Vapor initiated a number of developments to improve the ground contact sensing for preventing lift jacking of the bus. The original Vapor ground sensor design had one sensitive edge at the extreme outboard edge of the underside of the platform (excluding the safety gate, which is up when the platform descends), which ideally should contact the ground first. A second sensitive edge was added under the platform in a rectangular loop configuration, however, it was not successful in eliminating the jacking problem. A later modification was a limit on cylinder downward travel, which was intended to limit the load the lift can transfer from the road wheel to the lift. However, this modification is only effective when lowering the lift to the road surface; if the lift is lowered to curb level, the extra height of the curb negates the downward travel limitation, and the lift can still attempt to jack the bus to curb height if the ground sensor fails. The latest lift designs have load sensors built into the towers. The sensors stop downward travel when the platform weight is removed from them, which is the first force change that occurs when the platform contacts the ground. At present, Milwaukee considers the modifications unfeasible for retrofit on its lifts.

3.7.4 Problems Reported

Bus jacking remained a major problem as reported in repairs required for cylinders, linkage elements, bushings, bearings, and deploy arms. Electrical problems were also frequently reported, as well as the microswitch problems discussed earlier. Dust and dirt entry through unsealed gaps in the installations has also been cited as a problem.

SECTION 4
SITE VISITS

The site visits are summarized and presented in alphabetical order in this section. In addition to the sites selected for comprehensive assessments, data and experiences recorded at San Mateo County Transit (Samtrans) and at Alameda-Contracosta Transit (AC Transit), which were briefly visited as part of the assessment at Santa Clara County Transportation Agency (SCCTA), are included. Thus, a total number of seventeen site visits are described.

The same basic format is used for presentation of site data. First, a brief statement of the lift/bus installation assessed along with dates, and persons contacted. This is followed by a review of the site and system characteristics including size, environment, type of operation, ridership and road call data to establish the level of service reliability and driver training and procedures. Data on lift repairs and problems is presented next, followed by data on maintenance procedures and training of mechanics. Where warranted, a summary paragraph is provided on the overall conclusions from the experience at the site.

4.1 BLOOMINGTON-NORMAL PUBLIC TRANSIT SYSTEM (BNPTS), IL

BNPTS operates 23 TMC Citycruisers equipped with TDT-30 lifts which were delivered from June, 1980 through January, 1981. The site was visited July 13 and 14, 1981 and discussions were held with Peter Webber, Executive Director and other BNPTS personnel.

4.1.1 Site and System Characteristics

Bloomington-Normal, Illinois is a small/medium sized community with a population of 69,000 and a moderately severe climate. The average January minimum temperature is 18°F (-10°C) and frozen precipitation averages 22" (55.9 cm) annually. July maximum temperatures average 87°F (31°C) and annual rainfall is 33" (83.8 cm). The terrain is level.

4.1.2 Operations

BNPTS provides regular (Monday through Saturday) fixed route service which requires 12 buses and an origin-to-destination, advance scheduled service known as Will-Call (W-C). This latter service has some aspects of fixed route service based on core routes operated by the W-C buses. Individual users can schedule repetitive trips permanently (i.e. until they cancel) with BNPTS, such as a large group which travels daily between a mental retardation center and the Occupational Development Center. Routes may be different from run-to-run based upon additions or deletions; however, random street corner boarders are not accepted, and rides must be scheduled 24 hours in advance. There is no formal qualification procedure for use of W-C, but the service is restricted to handicapped users, and age alone is not considered a handicap. Drivers monitor the clients picked up, and if there is some uncertainty as to a person's disability, a medical certificate be required. The W-C operates Monday to Friday, and uses two buses full-time and one part-time, from a fleet of four buses which are equipped with three wheelchair positions.

4.1.2.1 Ridership - The fixed routes have no wheelchair trips during the week, and very few, if any, wheelchair trips on Saturday - the records are imcomplete in this area, but was estimated at about three trips each Saturday. W-C service averages about 3,500 trips per month and about 15% of the riders require use of the lift. This represents about six lift trips per fleet bus per day, much higher than the most intensively used regular fixed route buses investigated in this project.

4.1.2.2 Driver Training - Wheelchair trips are concentrated on the W-C service, therefore, the fixed route drivers do not have the opportunity to retain familiarity with the lift. The four W-C drivers are considered to be familiar with lift operation, although all drivers were initially trained in lift operation. The lift training procedure was developed by the BNPTS maintenance and operations supervisors. There have been no safety incidents of note with the BNPTS lifts. W-C driver are allowed to assist passengers getting on and off the bus when necessary, but are instructed not to leave the immediate area of the bus unless an emergency arises.

4.1.3 Lift Experience

The intensity of use in the W-C service coupled with a limited number of drivers (two full-time and two extra board) who are familiar with the lift has resulted in a very reliable operation. For the 11 months, through June of 1981, only seven road calls related to lifts had been recorded; two occurred in January three in February and one each in May and June. The actual number of road calls for W-C buses could not be determined from the available data. Very few parts were replaced up to June of 1981. The total parts consumption on four lifts is:

Item	Quantity
Front Slide	2
Rear Slide	2
Ramp Weldment	1
Sliding Panel	1

All were replaced while the lifts were under warranty. The warranty from TDT is 90 days, but TMC warrants the bus and equipment for one year, and thus is assuming the cost of the extra nine months themselves. Based on other data, parts costs are estimated to be less than $1,500. Labor costs for lift maintenance are not separated out.

The details of road call causes are not known, but lift drifting is a common occurrence and accounts for some, if not most, of the road calls. Lift drifting down (or up) when stowed is a recurring problem. There is no mechanical lock on the lift in the stowed position; only a hydraulic lock provided by trapped hydraulic fluid when the up/down actuator valve is in the off position. Drifting is caused by internal leakage in the valve. There is a hydraulic accumulator in the system which provides the necessary energy to cause a lift to drift up even when the engine is off, although most lifts drift down. When the lift drifts down, it opens a spring-closed door on the underside of the lift. If this occurs while the bus is in service, and the driver does not notice that the lift is drifting down, the door eventually catches on the road and is bent or torn off. These doors, which are not part of the TDT design, but were added as additional weather protection by TMC, are now being removed by BNPTS.

BNPTS has made a bar which can be inserted under a lift in the step mode to control downward drifting. The TDT-30 lift can be raised and lowered in the step mode. To insert a bar, the steps are raised several inches to allow the bar to be placed on fixed flanges adjacent to the lift. Then the steps are lowered to rest on the bar and to trap it in place. The bar is not otherwise fastened in. Two fixed route buses currently have the bars in place. The support bars are considered a temporary expedient for problem lifts, and are not being applied on a fleet basis.

Other problem areas experienced with the TDT-30 lift by BNPTS include:

1) Loss of sychronization between the two lift cylinders. When this happens, the steps/platform are no longer parallel with the bus floor because one cylinder piston is higher than the other. It is necessary to remove the side panels to readjust the relative piston positions for the two cylinders.

2) Microswitches which get out of adjustment easily. The microswitches on the doors, which sense that the doors are fully open and allow the lift cycle to be initiated are a particular problem, but they are not part of the TDT supplied package. No lift microswitches were reported as used in the parts consumption data.

3) Rolling up of the pressure-sensitive ground sensor mat on the underside of the platform as the platform folds to steps. This shorts out the mat, which must be unrolled and re-attached. No safety mats were reported in the parts usage.

As indicated earlier, the major repair efforts have been on the W-C service buses, on which it has been necessary to replace four slides, a ramp weldment, and a sliding panel. The slide assemblies are particularly vulnerable to dirt accumulation, and wore to the extent that the ball bearings came out of the retainers. This repair was reported as being particularly time consuming because it requires a substantial disassembly of the lift.

4.1.3.1 Servicing and Training - Lift shop inspection and preventive maintenance is performed every 5,000 miles. The PM procedure consists of operating the lift to check for binding, inspection of the hydraulic lines, and grease lubrication of the slides. The drivers are supposed to cycle the lift once a day to check its operation.

Three mechanics perform all of the bus maintenance, including the lift maintenance. The three mechanics attended a two-day seminar on lift maintenance by TDT personnel arranged by and given at BNPTS along with mechanics from the other four Illinois cities with similar lifts. The seminar covered primarily mechanical and electrical aspects of the lift, with some instruction on operation of the lift. There is a maintenance manual for the lift which was reported to be outdated.

4.1.4 Summary

Although the TDT-30 lift is technically obsolete and BNPTS appears to have experienced the same problems encountered by other operators, it has been able to offer reliable service. The major factors in this appears to be the frequency with which the lift is used and driver familiarity with lift operation.

4.2 CHAMPAIGN-URBANA MASS TRANSIT DISTRICT (MTD), IL

The MTD operates a fleet of 25 EEC lift equipped GFC 870's and also has 15 retrofitted GMC new look buses. The site was visited on July 16 through 18, 1981 and discussions were held with R. Grear Kimmel and William Volk.

4.2.1 Site and System Characteristics

Champaign-Urbana has a population of 100,000 and is a community with a public policy in favor of accessibility. This is, in part, due to the presence of the University of Illinois which was for many years a pioneer organization in providing services to handicapped students, including a campus transportation service. The MTD is also the recipient of a UMTA demonstration grant for a totally accessible transit system. The climate is moderately severe being virtually identical to that of Bloomington-Normal which is only 150 miles distant.

4.2.2 Operations

The MTD policy is to provide 100% accessible service on selected routes until it can be provided on all routes. At the time of the site visit, service delivery was being constrained by bus availability due to two causes. First, there were continuing problems in making the retrofitted buses reliable enough for service. Second, the need to make frame and other repairs on the GFC 870 buses. At the time of the site visit, the MTD estimated their average 870 fleet availability status as:

Total Buses in Fleet	25
Buses Under Repair	13
Frame	2
Lifts	3-4
Other	≤8
Buses Available	11
Peak Requirement	9
Actual Reserve	2

4.2.2.1 Ridership - Table 4.2-1 shows the ridership and related road call experience on the accessible routes for the period July of 1980 through July of 1981. Apart from a slight seasonal decline, the ridership appears to have reached a fairly stable level of about 90 trips per month with some continuing improvement in road call performance in the later months.

4.2.2.2 Driver Training - MTD developed training procedures and aids to suit its own requirements. The initial driver training provided two hours of classroom presentation, followed by two hours of hands-on lift operation training on the buses.

The classroom sessions consisted of a verbal introduction to the lift, followed by an MTD - prepared slide-tape presentation on accessibility and human relations relating to the lift, and the operation of the lift. The presentations were followed by open discussion among the drivers and two representatives from the handicapped community. The discussion sessions helped to allay drivers' fears and questions concerning the appropriate manner of dealing with handicapped people.

The operational training on the bus was conducted by two drivers at a time, with each driver alternating as either the bus operator or as a wheelchair passenger so that each driver could experience the lift. Training routes were designed to encounter all of the possible boarding situations, such as stops with curbs, no curbs, etc. Although the 25 Flxibles were received in April, 1980, accessible service was not instituted until June, to allow time for drivers to become familiar with basic bus operation, as well as to allow time for lift training.

4.2.3 Lift Performance

The performance of the EEC Model 120 lift on the Flxible 870's is regarded as generally satisfactory by MTD, with some exceptions. At the time of the site visit, it appeared that an overall improvement in the on-the-road performance had been taking place based on the most recent records. Up to that time, lift performance could only be regarded as average. There had been one campaign on the lift to change out defective parts, and a second campaign was to follow. The first campaign was for a part designated the "K-shaft." The original parts had suspicious

Month		Wheelchair Lift User Ridership	Road Calls	Riders/Call
July*	1980	48	0	∞
August	"	57	5	11.4
September	"	93	5	18.6
October	"	95	6	15.8
November	"	49	3	16.3
December	"	51	9	5.6
January	1981	72	6	12.0
February	"	55	7	7.9
March	"	91	9	10.1
April	"	91	8	11.4
May	"	63	5	12.6
June	"	86	1	86.0
July**	"	48	1	48.0

*Partial month.

**First 15 days. Ridership is estimated for total month.

TABLE 4.2-1: WHEELCHAIR LIFT USER RIDERSHIP AND ROAD CALLS ON GFC 870 BUSES AT CHAMPAIGN-URBANA welds, the failure of which could drop the lift platform to the ground. The second campaign was planned to replace the welded K-shaft assembly with a one piece forging.

MTD reported other problem areas with the lift as:

1) Interlock system and switch failures. Most of the failures appear to be in the adjustment of the devices; the available warranty records show only three switches used and four other claims for unspecified electrical work, with no parts used.

2) Failures of the main pump ($1,700). MTD reported that three of these had been replaced, although only two are recorded in the available records.

3) Control box ($1,525) failures of which eight were claimed and five were recorded in the available records.

4) A third item reported to be troublesome is the level sensor. However, MTD warranty records do not show any of these devices replaced under warranty.

5) Winter associated problems such as stiffening of hydraulic fluids and lubricants; slush and grit accumulation on the lift, and the use of corrosive road solvent in the Champaign-Urbana area that appears to be detrimental to the lift. (The solvent is not salt - MTD could not state with certainty the exact solvent used.) The 2,000 mile inspection period used is not frequent enough in winter to control corrosion at some steel to aluminum interfaces. MTD is of the opinion that certain bearings in the aluminum housing should be bronze or brass bushed.

6) Fatigue failure of the welds at the base of the handrails (Figure 4.2-1).

It was not determined if the MTD pumps were salvageable to any extent, which would normally be possible for an item of this nature. However, the control boxes which contain a printed circuit board and other devices are intended to be replaced in total. MTD is of the opinion that a test board for the control box would be useful to enable a transit operator to repair the module.

MTD has undertaken two hardware modification programs of its own for the lift. One of these is a simplified outer safety barrier. The new barrier is somewhat shorter than the EEC barrier, and does not have an intermediate bend. The cost of the MTD barrier is on the order of 20% of the EEC replacement part. The outboard barrier, which also serves as the entrance ramp to the platform, has been damaged on several lifts by contact with the road or curbs. The outboard barrier is normally folded under the lift and is retained in the full-up position by ramps that lift and secure it during the last increment of travel as the platform stows in the step mode. If the steps drift outward, the barrier is released and can drop slightly. In this position, the barrier can catch and be damaged as the front of the bus passes over a curb such as when negotiating a corner (Figure 4.2-2).

A second modification to the lift made by MTD is the addition of a small metal foot at both outboard corners of the platform. The feet keep the lift platform and wheelchair weight off of the outboard barrier actuating cylinder and mechanism.

All the buses were still under warranty, but the records available for inspection were incomplete and the extent of the missing data could not be determined. The available records comprised 16 repairs requiring 39.5 hours of labor over a period from July of 1980 to April of 1981, but with no repairs recorded for the three months of September through November of 1980. The greatest number of repairs listed was five in January of 1981 for a total of 17 hours of labor. MTD's monthly service summary shows 75 hours of lift related maintenance for this month and it is unlikely that all of this difference can be accounted for by the 2,000 mile inspection and preventive maintenance procedure.

4.2.4. Lift Maintenance

The lifts are cycled about every two days to check for proper operation. The basic preventive maintenance cycle for each bus is 2,000 miles, during which the lift is cycled, the oil levels checked, and the lift is lubricated at several points. Although each bus has a more extensive PM at 6,000 mile intervals, the lift PM is the same as the 2,000 mile inspection. The Flxible buses presently accumulate about 44,000 miles per year.

4.2.4.1 Mechanic Training - MTD has 8 full-time mechanics, 2 part-time mechanics, and 3 supervisors who were sent to Flxible for a one week training course for the Flxible buses. The one week course covered all bus systems, including the lift. In addition to the training at Flxible, one Flxible electrical engineer spent a week at MTD reviewing electrical systems on the bus, including the lift electrical

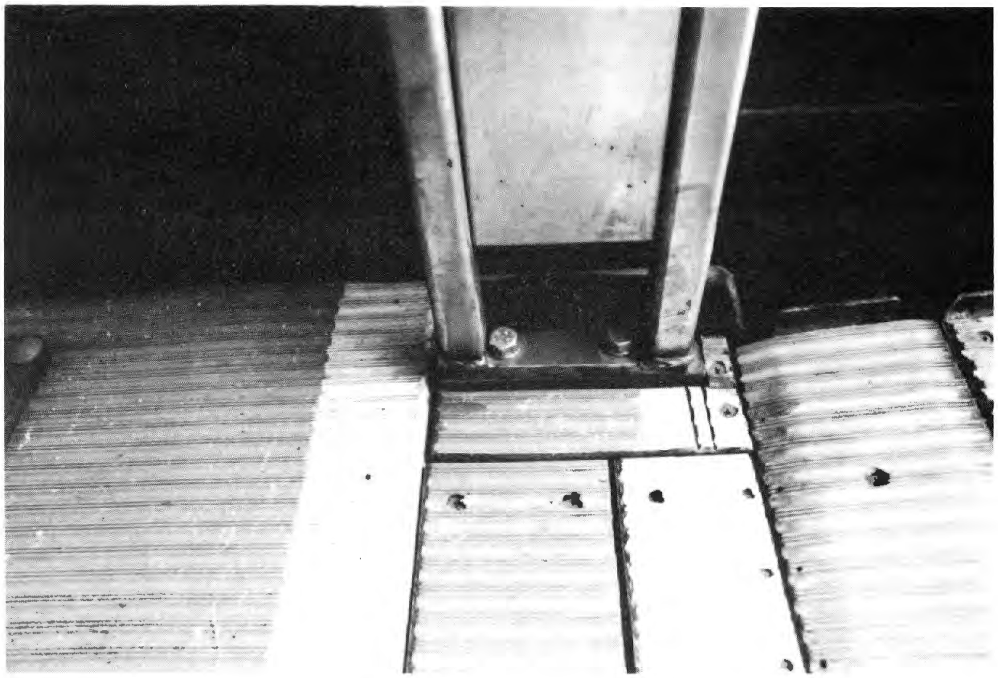


FIGURE 4.2-1: HANDRAILS REWELDED AT THEIR BASE ON EEC 120B LIFT

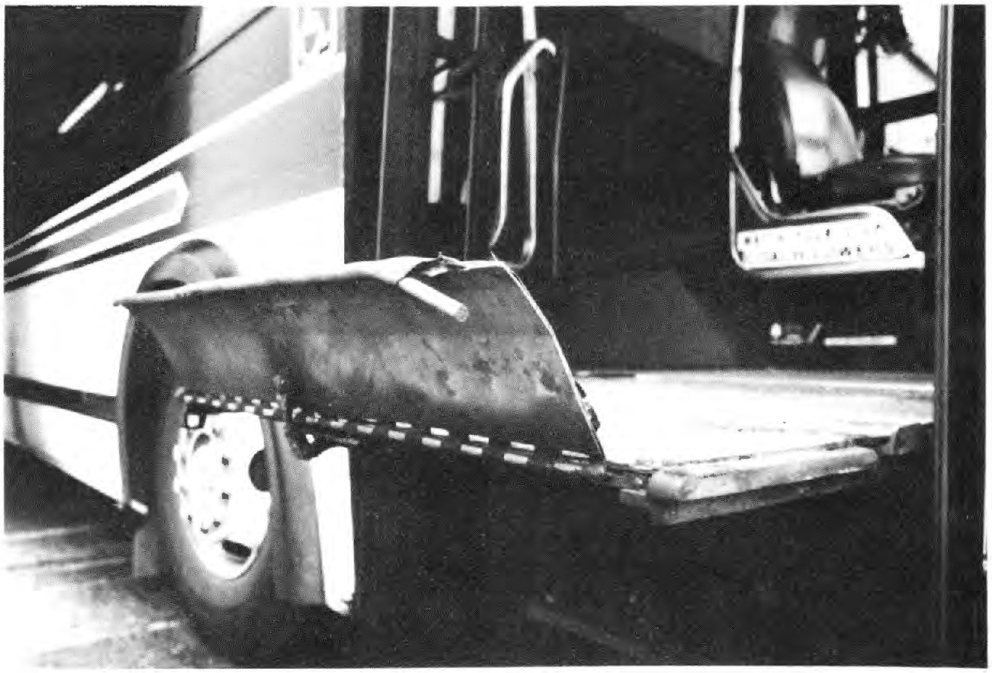


FIGURE 4.2-2: ROAD DAMAGE TO DRIFTING SAFETY BARRIER ON EEC 120B LIFT

system, with MTD mechanics. A second Flxible engineer, a lift specialist spent three days at MTD working closely with three mechanics specifically on lift maintenance.

4.2.5 Summary

MTD felt that the EEC lift had been generally satisfactory but full deployment had been curtailed by other problems with the buses.

4.3 DENVER REGIONAL TRANSPORTATION DISTRICT (RTD), CO

The RTD operates a fleet of 313 GMC and AMG buses equipped with EEC Model 140 lifts which can be categorized into three groups.

10 - GMC "New Look" buses, originally retrofitted with EEC Model 110 lifts, retrofitted a second time with Model 140 lifts.

176 - AMG buses retrofitted with Model 140 lifts over the period from November of 1980 to September of 1981.

127 - GMC "New Look" buses, from Canada, fitted with MOdel 140 lifts as original equipment and delivered from March through May of 1981.

All 313 of the Model 140 lifts use the same modifications as a deliberate policy, so that there is only one version of EEC lift on the property. Having only one version of a lift simplifies maintenance, spare parts inventory, and operator training. None of the AMG buses were in accessible service because internal changes for wheelchair securement had not been decided upon. The AMG buses are used in regular service with lifts cycled every day by the drivers and the lifts receive the same maintenance as the other lifts.

The site was visited September 2 through 8, 1981 and discussions were held with many personnel including Mike Smith (Acting Director), Tom Bell (Operations) Marvin Ornes (Maintenance) and Larry Olgean (Training).

4.3.1 Site and System Characteristics

The Denver metropolitan area is the 17th largest in the U.S. with a population of just over one million. In addition to its high altitude, the region has a moderately severe climate with an average annual precipitation of 60" (152.4 cm) of snow, ice, and hail and only 9" (22.9 cm) of rain. Minimum January temperatures average 16°F (-9°C) and the average July maximum is 87°F (31°C).

4.3.2 Operations

The RTD provides fixed route services throughout the Denver region, including the City of Boulder. RTD operates over 500 buses with a peak fleet requirement of 450. The new GMC (Canada) and older GMC buses are currently in accessible service; the older ones being used for downtown circulator service.

The 137 GMC buses were assigned to seven routes in Denver and two routes in Boulder as follows:

		Buses Assigned	Buses Required
GMC (Canada) 4801-4927			
Routes 0, 1, 15, 30, 38	Denver	117	80
202, 204	Boulder	10	6
GMC (Retrofit) 1260-69			
CCE, CCW Denver		10	2

This service pattern had only been started in June of 1981 so that operational experience was limited. RTD provides weekly summaries of lift usage (from drivers' record cards) and lifts reported out of order based upon the driver's daily predeparture check-out and road call records.

4.3.2.1 Ridership - Using data for the week's commencing June 7 through August 23 the on-the-road performance for the first three months of service has been estimated as shown in Table 4.3-1. Ridership was still increasing and road calls were averaging about one for every ten wheelchair trips. This appears to be on a par with the experience of operators using other EEC lift models. Figure 4.3-1 shows the history of road calls for all three of the bus groups. Because of the change in service structure in June of 1981 the prior period cannot be directly compared to the later period. It would appear, however, that the retrofitted 140 installation in the GMC's did not prove to be significantly superior to the previous lift model. The absolute number of road calls dropped a little, but this may reflect the change in service patterns. The percentage of road calls attributed to lift problems did not change appreciably. The data for the AMG buses indicate that some low level of lift-related road calls may be expected even when the lifts are not in accessible service.

Fleet:	GMC(Canada)-4800/4927						GMC-260/269	
Location:	Denver		Boulder		Total		Denver	
Month	Riders	Road Calls	Riders	Road Calls	Riders	Road Calls	Riders	Road Calls
June*	464	44	10	5	474	49	34	6
July	776	53	14	0	790	53	92	10
August**	812	74	27	7	839	81	68	7

*From June 7th.

**Monthly ridership includes estimated figures for August 30th and 31st.

TABLE 4.3-1: RIDERSHIP AND ROAD CALLS OF REVISED ACCESSIBLE SERVICE AT RTD, DENVER

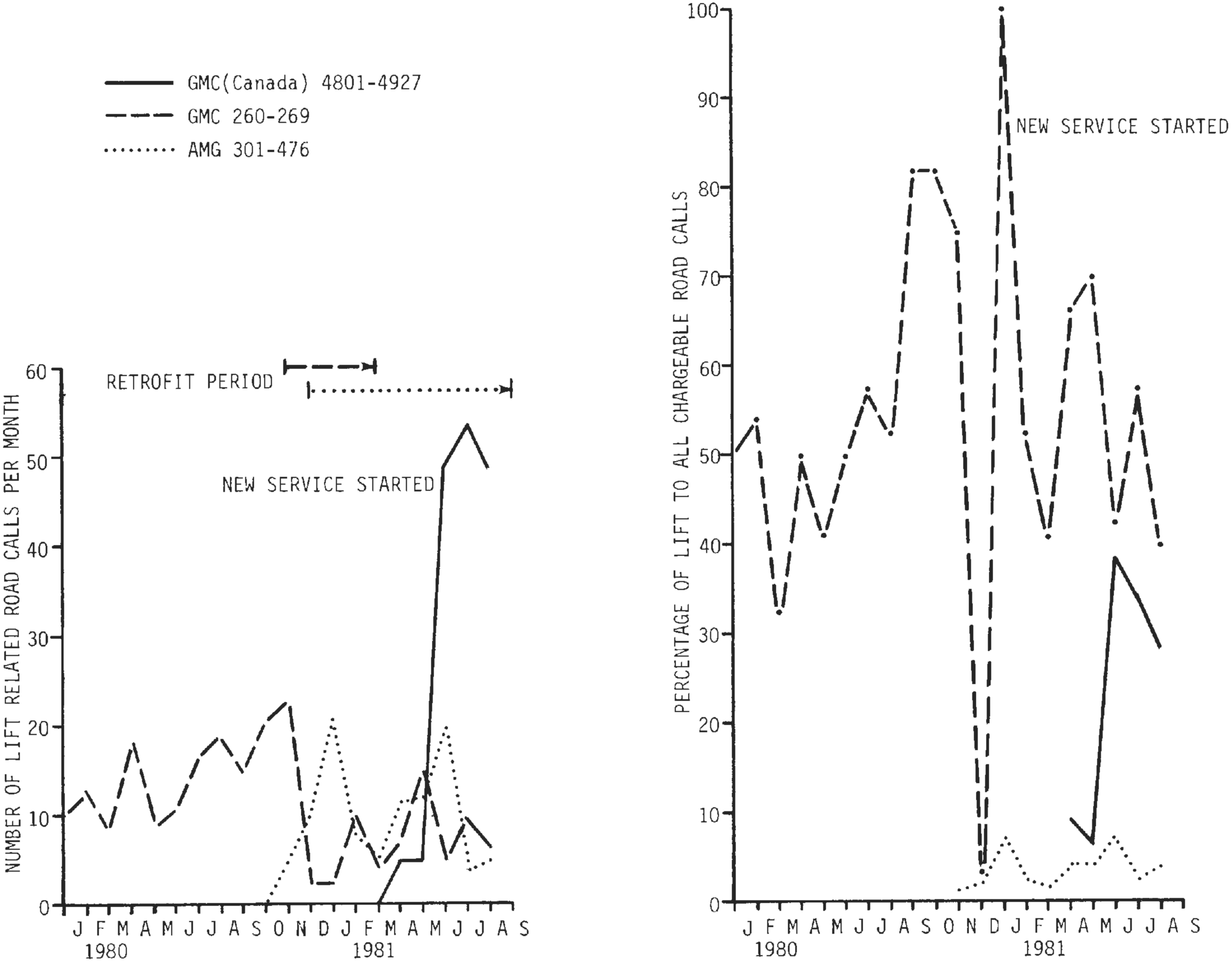


FIGURE 4.3-1: ROAD CALL PERFORMANCE OF ALL THREE LIFT BUS FLEETS AT RTD, DENVER

4.3.2.2 Driver Training and Procedures - All drivers are trained in the operation of all three lifts which RTD operates - the EEC, TDT, and an active lift made by FMC. The 8 hour course consists of approximately 4 hours of sensitivity training and 4 hours of lift operation training. As a training aid, RTD produced 3 presentations: a video tape presentation that explains the origin and nature of disabilities; a film that explains the feelings of handicapped persons (both produced with the assistance of Craig Hospital in Denver), and a film on lift operating procedures produced by RTD alone.

RTD prepared their own driver training program for EEC lifts using data provided by EEC, but considerably expanded to suit RTD's needs. RTD has prepared individual operator's manuals for the EEC and TDT lifts, and a booklet, "Operators Handbook: How to Assist Elderly and Handicapped Persons."

For each lift, the instructor completes an evaluation form rating the student's ability to operate the lift and securement devices, and knowledge of accessible routes. Each student, at completion of training, must sign a form indicating that the training has been thorough and complete.

Road supervisors and dispatchers are also trained in operation of the lifts. The road supervisors appeared to have lost some familiarity with lift operation due to infrequent encounters with lift problems; however, the dispatchers were quite proficient at handling lift problems over the radio, especially in dealing with commonly recurring problems.

Drivers are instructed to operate the lifts as part of the pre-departure bus inspections which they are expected to perform each day. Most drivers were conscientiously checking the lift, therefore, RTD had little problem with regular accessible route drivers losing familiarity. Drivers bid their routes every three months, based on seniority, and as a result drivers not familiar with lifts may bid onto, or be forced onto, accessible routes. Drivers are paid 15 minutes overtime to check all bus equipment prior to departure, including the lift, if the bus is so equipped; however, there is no extra pay associated specifically with lift checkout or operation.

RTD has assigned an instructor permanently to each garage to provide training and assistance to drivers on all aspects of bus operation, including lifts. Providing occasional refresher courses to drivers for lift operation was not considered a major burden. The need for such courses is expected to disappear when all buses are lift equipped.

4.3.3 Lift Experience

The model 140 lift retrofits on the 10 GM buses and the 176 AMG buses were done by an engineering division of the Readi-Mix Corporation in Denver, under contract to EEC (not RTD). In addition, all warranty work on all 313 model 140 lifts (including the 127 lifts installed on new GM buses) is done by Readi-Mix who employed approximately 15 people to retrofit the AMG buses and to handle the warranty work. All lifts were still under warranty in September of 1981 and as a result, RTD did not have complete records of the lift repair effort, especially labor hours.

RTD performed basic preventive maintenance on the EEC lifts, which consisted of inspections, lubrication, and minor adjustments. Malfunctions that RTD couldn't fix, or determine the cause of, were sent to Readi-Mix. Fully 25% of the buses sent to Readi-Mix were returned to RTD with no action taken, because the reported malfunction could not be detected at Readi-Mix. RTD was certain that mechanics observed the symptoms reported and noted that many driver reports of malfunctions could not be confirmed by RTD mechanics. These buses were not forwarded to Readi-Mix. Although some incidents were attributed to driver error, RTD believed that in most cases drivers' reports were conscientious and accurate, and the inability to duplicate a malfunction was an indication of an intermittent fault. One known cause of intermittent failures was internal breaks within wires.

The repair records at Readi-Mix for the period of November through August of 1981 were examined and the actions taken recorded and analyzed. This covered 376 repairs of which 94 (25%) were recorded as no problem found situations. The distribution of the other repairs between the three vehicle fleets was as follows:

Fleet Series: Model:	4800-4926 GMC (Canada)	260-9 GMC (Retrofit)	300-475 AMG (Retrofit
Number of Buses	127	10	176
Month/Number of Repairs:			
1980			
November			2
December		2	12
1981			
January		4	29
February		7	12
March	Buses	1	3
April	Delivered	2	30
May	8	6	14
June	34	0	12
July	26	2	8
August	52	8	8
TOTAL	120	32	130

The repair rates of the two fleets of GMC vehicles used accessible service were approximately equal using this limited data base. The corrective actions necessary to effect these repairs were grouped and tabulated for the three fleets. This involved over 30 actions on the two larger fleets and over 20 on the smaller fleet. Typically, a small number of these actions accounted for the majority of the repairs. Table 4.3-2 lists these actions indicating numerous similarities, and at least one significant difference. The replacement of hydraulic actuators is not as numerically significant on the AMG buses and are uniformly spread over the time period covered. The actuator repairs for the other two fleets do not show up until the accessible service change over in June and are of a much higher order of magnitude as shown below. John Hall, Chief Engineer, of EEC in a telephone coversation of 2/10/82 stated that the problem with the actuators was a bonding failure between the vane and the shaft which occured on a run of 200 units after

GMC(Canada) 4801-4927

Pinched/disconnected/broken wire
Replace/adjust level sensor
Replace rotary actuator
Replace pilot operated check valve
Adjust outer barrier linkage
Replace/adjust limit switch
Replace solenoids
Adjust/clean/replace barrier switch
Reattach ground wire to control box

GMC(Retrofit) 260-269

Broken/loose wire
Adjust barrier switch
Replace solenoids and valves
Replace rotary actuator
Replace broken bushings
Install pins, adjust linkage

AMG(Retrofit) 300-475

Pinched/disconnected/broken wire
Adjust valves
Replace/adjust level sensor
Tighten bolts, screws/install pins
Clean/repair Deutsh plug
Replace/adjust barrier limit switch
Adjust flow restrictors
Replace heelswitch
Install new down limit arms

TABLE 4.3-2: MAJOR REPAIR ACTIVITIES BY READI-MIX ON RTD, DENVER BUS FLEETS satisfactory production of 150 units. Although 100% tested at EEC, failure would not show up until many cycles were completed sometimes, as high as 50-60 cycles. The manufacturers procedures have since been corrected. The wiring failures were attributed to an overly tight harness, and this problem has also been corrected.

Month/Fleet	Number of Rotary Actuators Replaced GMC (Canada)	GMC (Retrofit)	AMG (Retrofit)
1980			
November	---	---	0
December	---	0	0
1981			
January	---	0	0
February	---	0	1
March	0	0	1
April	0	0	1
May	0	0	0
June	8	0	0
July	5	3	0
August	7	1	1
TOTAL	20	4	5

The AMG fleet conversion was not scheduled to be completed until September of 1981 so that the exact number of buses in the AMG fleet at any time cannot be stated with certainty. On a linear delivery schedule, the average fleet over this period would have been 80 buses, and during June through August of 1981, it would have been at about 140 buses. On either basis, the failure rate is significantly lower, and can be attributed to the buses not being in accessible service. The lifts on the AMG buses are not subjected to loaded cycles and the daily lift cycling may not be performed quite so routinely.

The rotary actuator on the 140 model lifts is of EEC design and manufacture with a list price (Summer of 1981) of $822.64. Therefore, a significant number of failures on such an item would represent a considerable expense after the expiration of any warranty period. For instance, the cost of the 24 failures in the first three months of the current accessible service would work out at $8.23 per trip just for materials without any added labor or overhead costs.

In all three bus fleets, the most frequent failures were due to pinched, broken, or loose wires in the underplatform circuits. The pinching generally appeared to require some minor rerouting of the wiring, however, the high rate of failure on the GMC buses appears to indicate a problem induced by flexing of the wiring harnesses during lift operation.

At the time of the site visit, there had been three recent accidents with 140 Model lift operations. In two of the accidents, the outer safety barrier failed to hold, resulting in two wheelchairs rolling off the lift as it ascended. The barrier failures were caused by failure of the barrier elevating mechanism to stay locked. As the lift begins to ascend, the initial motion is outward (away from the bus) as well as upward. In some situations, initial outward motion partially retracted the barrier elevating mechanism, so that the barrier could be pushed down by a wheelchair rolling against it. EEC responded quickly with a modification to correct the problem.

In the third accident, a person fell out of a wheelchair and off the lift, but the chair itself did not fall off of the platform. There is a lack of certainty about the circumstances of the accident, but there is a concern that a negative slope to the platform (away from the bus) could have been a contributing factor. The negative slope can occur in four ways:

1) In unfolding the steps into a platform, the platform first becomes straight at a high negative angle, then proceeds to level itself. If the driver released the "platform" switch after the platform is straight but before it levels, the leveling motion stops immediately. The platform is, then, available for a deboarding passenger to roll onto, even though it is at a high negative angle.

2) In a similar manner, a negative slope can occur when raising from ground level. When the "barrier-up" switch is actuated, the platform stiffens, the barrier erects, and the platform levels. If the driver releases the switch before the platform levels, it stays at a negative slope.

3) When the platform level sensor senses level at the ground, "barrier-up" simply stiffens the platform and raises the barrier, but no further leveling occurs. Then, when the platform is raised, the weight on the platform deflects it to a negative slope.

4) Level sensor tolerance. The EEC Service and Maintenance Manual for the 140 series lift indicates a ± 2 1/2 degree tolerance in the leveling mechanism. RTD has had the sensor setting changed to provide a minus zero to plus five degree setting to ensure that no negative slopes can occur.

The 140 model is simpler than the earlier 120 series but it requires more driver input since it does not have the continous leveling feature of the 120 series lift. RTD has posted a warning on the farebox for drivers to ascertain that the platform is level before boarding a wheelchair passenger. Figure 4.3-2 illustrates this together with the condition cautioned against.

4.3.3.1 Lift Maintenance - The maintenance procedures used at RTD are based upon the procedures outlined in EEC's manual, but with some important revisions. Figure 4.3-3 shows the four page procedure developed by RTD for the 6,000 mile service and inspection of the lift. The check marks indicate those items that are found in the EEC manual. The revisions cover three areas; cleaning, and preparation of the component to be serviced, extra steps within the inspection procedure itself, and integration of the lubrication cycle into the servicing sequence.

RTD initially deleted the lubrication of platform and barrier hinges from their schedule. This was due to concern that an excess or spillage of the motorcycle chain oil specified would cause the steps to become slippery. RTD has started to use a dry graphite lubricant (Dryslide) so that this fear no longer exists. Other potential changes indicated by RTD include specifying fluid level checks with the lift in the stowed position to avoid accidental displacement of fluid and checking for downward drifting under load.

FIGURE 4.3-2: NEGATIVE PLATFORM SLOPE CONDITION AND WARNING POSTED BY RTD

E.E.C. LIFT INSPECTION AND SERVICE

NOTE: Lift should be inspected and serviced with each 6,000 mile inspection of the vehicle.

NOTE: For best performance, it is essential that the lift be cycled at least once, and more often in cold weather, before the bus is dispatched for daily service runs. The lift operates slower when hydraulic fluid is cold, and the initial cycling prepares the system for normal operation.

A. Visual Inspection and Cleaning

1. Unlatch power package access door. (Located just rearward of right front wheel well). Carefully release locks and pull power package sliding tray outward only as far as attached harnesses and hoses will comfortably allow.

   Note: Dirt accumulation in the power package and sliding tray should be washed off at each inspection.

   Prior to Washing:

   - If the dirt accumulation is due to oil leakage, the origin of leakage may be more easily found by noting the area most oil soaked.
   - To lessen the possibility of oil contamination, assure the vent/filler cap is intact and secure.

   While Washing:

   - Avoid prolonged direct spray at:
     Vent/filler cap
     Logic box
     Amphenol connectors

   After Washing:

   - Used pressurized air to dry:
     Terminal strips
     Logic box
     Amphenol connectors

2. Examine power package sliding tray for physical damage or distorted enclosure panels.
3. Inspect tray area for damaged electrical wires, loose or corroded connections.
4. Inspect for damaged, nicked, or kinked hydraulic tubing.
5. Check for leak or seepage around pump and reservoir, manual hand pumps, check valve, hydraulic manifold and fittings.
6. Carefully clean around reservoir vent/filler cap before removing. Assure fluid level is to one inch from filler hole. Add to reservoir, if necessary the required amount of hydraulic oil. (See Section C).

FIGURE 4.3-3: RTD DEVELOPED P.M. PROCEDURE FOR EEC 140 LIFT

7. At coach front doors, check for loose covering on platform/stairs.

8. Examine for physical damage or distortion:

   Steps and risers
   Visible side panels
   Lift grab rail and fold-up seat

B. Operational Procedure

1.0 Pre-operation checks.

   1.1 Verify that the lift will not operate when the front doors are closed and "Master" switch is on.

   1.2 With "Master" switch on and front doors open, verify that the brakes are engaged and the accelerator disabled.

   1.3 Verify operation of warning lights.

   1.4 Verify warning beeper: 4800-4900 G.M. Coaches - When "Master" switch on; Retro-fit Coaches - When lift is operated.

   1.5 The "Master" switch light is "On," indicating power. Doors should be fully open. None of the following switches are "On": "Stop/Reset" switch, "No Step" switch, "Electric Overload" light.

2.0 Actuate the following switches.

   2.1 Platform Switch - Platform unstows and remains docked against bus floor.

   *Verify that the platform is in a level horizontal position and the outboard safety barrier erects.

   *At the control panel, verify that yellow "No Step" light is "On".

   2.2 Lower Switch - Inboard barrier erects with initial movement as platform lowers.

   *Verify "Lower" mode stops when outboard barrier is deflected upward.

   *Verify "Lower" mode stops when outer section of platform is supported.

   *Verify lift automatically stops "Lower" mode on ground contact.

   *Verify doors cannot be closed with platform down.

   2.3 "Barrier Down" mode requires actuation of: "Barrier Down" toggle, remote steps by-pass switch. Outboard barrier lowers and platform settles to form entrance ramp.

   2.4 "Raise" switch - no function.

   2.5 "Steps" switches - no function.

   2.6 "Barriers Up" switch - outboard barrier erects and platform automatically levels.

FIGURE 4.3-3: RTD DEVELOPED P.M. PROCEDURE FOR EEC 140 LIFT (continued)

2.7 "No Step"
2.7 "Raise" switch - raise platform to approximately two (2) feet above ground level.

2.8 "No Step" by-pass mode:

*Verify operation of the "No Step" by-pass mode, actuate switches as follows:

<u>Note</u>: The "No Step" by-pass mode is provided to allow the operator ramp formation on uneven terrain, where it is possible that the lowering limit switches do not make contact. It may also be used if there is a failure in the "Steps" switching circuit.

- o Push "Stop/Reset" switch - light in switch will be "On" light in "Master" switch will be "Off".
- o Push "No Step" switch (yellow light) while actuating "Steps By-Pass" auxillary switch. Outboard barrier lowers and platform settles to form entrance ramp.
- o Push "Stop/Reset" switch - light will be "Off". Master switch will be "On".
- o "Barrier Up" switch will return lift to horizontal level with outboard barrier erect.

<u>Note</u>: At this time, with lift extended and two or three feet above floor level, a further visual inspection of the lift module can be made.

1. Examine lift assembly for physical damage or distorted structures.
2. Inspect for damaged electrical wires and loose connections.
3. Inspect for damaged, nicked or kinked hydraulic tubing.
4. Look for leaks or seepage around hydraulic cylinders, valves, and fittings.
5. Check for loose covering on platform.
6. Examine pivot bolts on actuator to platform linkage-assure bolts are not turning in the member to which they are threaded.
7. Check bushings or pivot points. Report any damaged or missing.
8. Lubricate lift as indicated in <u>Section C</u> of this directive.
9. Note any downward drifting of lift.
10. Verify operation of manual hand pump assemblies:

    - o Move selector level of Steps/Platform hand pump to "Steps" position. As the pump is stroked, the outer end of the platform will move downward toward the floor.

FIGURE 4.3-3: RTD DEVELOPED P.M. PROCEDURE FOR EEC 140 LIFT (continued)

- o Move selector lever of Steps/Platform hand pump to "Platform" position. Stroke hand pump until platform is again horizontally level. Reset Steps/Platform selector lever to center, neutral position.
- o Move selector lever of Raise/Lower hand pump to "Raise" position. Stroking hand pump will cause the entire lift assembly to move upward toward coach floor.

NOTE: If lift assembly is outward of apex, when pump is placed in "Lower" position, the lift assembly may drift out and down. This is normal due to gravitational assist.

- o Upon completion of hand pump tests, assure both selector levers are at center, neutral position.

2.9 "Raise" switch - platform raises to bus floor level, inboard barrier lowers.

*Verify smooth and soft docking action.

2.10 "Step" switches independently - no function.

2.11 "Step" switches (2) - platform stows into step position.

*Verify that the outboard barrier lowers and stows.

*Verify yellow "No Step" light on panel is "Off".

2.12 Check that time necessary to complete one cycle is within requirements.

2.13 Verify toggle control switches are smooth functioning and return to original position when released.

C. Lubrication

NOTE: Lubricate at each minor vehicle inspection.

Lubricate	Lubricate Type
Outboard barrier sliding mechanism	Aluminized grease
Alemite fittings (Zerks)	Non-Fibrous bearing grease
Hydraulic reservoir	Shell tellus 32
	Or Phillips 66 Magnus A: +30°F to +125°F Aeroshell 23: -40°F to +125°F

FIGURE 4.3-3: RTD DEVELOPED P.M. PROCEDURE FOR EEC 140 LIFT

4.3.3.3 Mechanic Training - As a large fleet operator, RTD provides training for its mechanics in all phases of bus maintenance, including lifts. RTD was not responsible for most of the EEC lift maintenance until the lift warranties begin to expire in November, 1981.

There were no maintenance manuals prepared for the EEC model 140 lift; therefore, RTD had to develop their own maintenance course from basic engineering documents (assembly drawings, electrical and hydraulic schematics) and physical inspection of the lifts. With frequent revisions and modifications to the lift, RTD often found wiring schematics inadequate and incomplete, and already outdated when received. Consequently, RTD had to prepare their own wiring diagrams from physical inspection of lifts.

The continuing development of the lift meant that the mechanics training became outdated and only the basics of lift operation remained valid. Changes to the lift have occurred during courses that negated several hours of instruction for a class. The lift course is now about 45 hours in length, conducted over seven weeks. About 90% of the time is spent on the EEC lift, most of the remainder on the TDT lift, with some coverage of the FMC active lift if time permits.

At the time of the visit, RTD did not have an EEC lift for instruction purposes. Demonstration and hands-on training for the class was conducted with a bus borrowed from the operating department. It was common for the class to have to first troubleshoot a lift before being able to observe it operating normally.

4.3.4 Summary

RTD was making an extensive effort to provide service with good in-house facilities. Appreciable ridership was being generated with the revised service but delays in bringing some fleets to operational status reduced the amount of data available. Some quality control and potential safety problems were identified.

4.4 CITY OF DETROIT DEPARTMENT OF TRANSPORTATION (DDOT), MI

DDOT operates 235 accessible GMC RTS-2 buses purchased over a three year period as follows:

1978	39 buses
1979	121 buses
1980	75 buses
TOTAL	235 buses

These buses represent 28% of DDOT's total fleet of 806 buses. The system was visited from June 7th through June 9th, 1981. Included in the discussions were Dick Golembiewski, Superintendent Vehicle Maintenance, George Nobles, Assistant Superintendent of Transportation and Robert Sutter, Senior Foreman-Shoemaker Garage, and Bill Swanger, Senior Assistant Mechanical Engineer.

4.4.1 Site and System Characteristics

DDOT provides regular urban fixed route bus service within the City of Detroit. Many of the routes operate 24 hours a day. Although the terrain is flat, road and traffic conditions are bad with many of the routes running through economically distressed areas. The climate is moderately severe with 23 inches (58.4 cm) of rain and 32 inches (813 cm) of snow, ice, and hail together with an average July maximum of 83°F (28°C) and an average January minimum of 19°F (-7°C).

4.4.2 Operations

DDOT has a peak fleet requirement of nearly 900 buses and the lift equipped buses were primarily operated upon four routes which are scheduled to be fully accessible. If other accessible buses are available, they are scheduled into other routes whenever possible. It should be noted the SEMTA E/H services also operate within the DDOT service area.

4.4.2.1 Ridership and Road Calls - Apart from some pre-service publicity, no real effort was made to promote the service and ridership has been very low. Based on the requests turned in by drivers (for which they require a $.50 premium), the total ridership in 1981, to mid-June had been 93. According to DDOT, this total is understated because the paperwork involved is known to deter drivers from filing premium claims.

During the early months of operation, the drivers were instructed to cycle the lift at the end of a run or at some convenient layover point to ensure that it was working. Using this procedure resulted in frequent failure which required numerous road calls, consequently, the practice was abandoned. In November of 1980, DDOT computerized their road call data on a weekly basis. Analysis of those records for the six month period through April of 1981 showed 45 wheelchair lift related road-calls of which 16 required that the bus be replaced in service. Total road calls for DDOT averaged 416 per month over the same period. Lift ridership during this period was approximately 80. Approximately three quarters of the road calls occurred during January, February, and March 1981. The weather during these months was particularly bad and numerous problems were also experienced with the kneeling feature. Use of this feature is recommended in GMC's standard operating procedure for the lift, but it is not known whether any such incidents are recorded under the lift calls.

4.4.2.2 Driver Training - Driver training was conducted over a two day period and included lift operation and passenger role playing. DDOT was just starting a refresher course of driver training at the time of the site visit. As a result of their initial experiences DDOT developed their own numbered lift operating sequence and decal to replace that supplied with the bus. DDOT believes it is simpler and more easily understood by operators who only occasionally use the lift in service (Figure 4.4-1).

4.4.3 Lift Experience

Only one division, Shoemaker, had experience with all three model years of the buses, therefore, the evaluation of maintenance and data aspects was concentrated at that garage. DDOT had been unable to hire extra mechanics due to budgetary constraints at a time when labor demands were increasing due to the introduction of the RTS-2. DDOT figures indicated an overall doubling of the man-hour requirement for maintenance on the RTS-2 compared to their previous GMC buses.

CAUTION: Before operating wheelchair lift, transmission shift lever must be in the "N" NEUTRAL position with the parking brake ON and the rear doors must be open with WHEELCHAIR LIFT MASTER switch in the ON position. Also, insure that the coach is positioned so there is no obstruction to the lift operation.

TO LOWER PLATFORM

Step 1 - Turn power switch on

Step 2 - Push platform deploy switch up

Step 3 - Push platform switch to down position

Step 4 - Push restraint switch to down position

TO RAISE PLATFORM

Step 5 - Push restraint switch to up position

Step 6 - Push platform switch to up position

TO PARK PLATFORM

Step 7 - Push both platform unlock and platform park switch at the same time

Step 8 - Turn Power Off

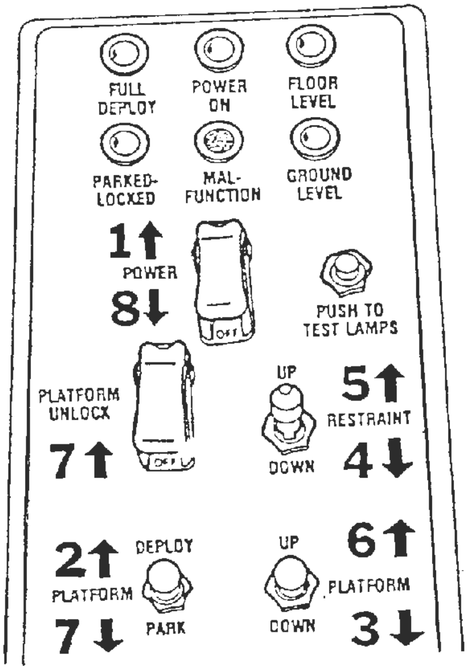


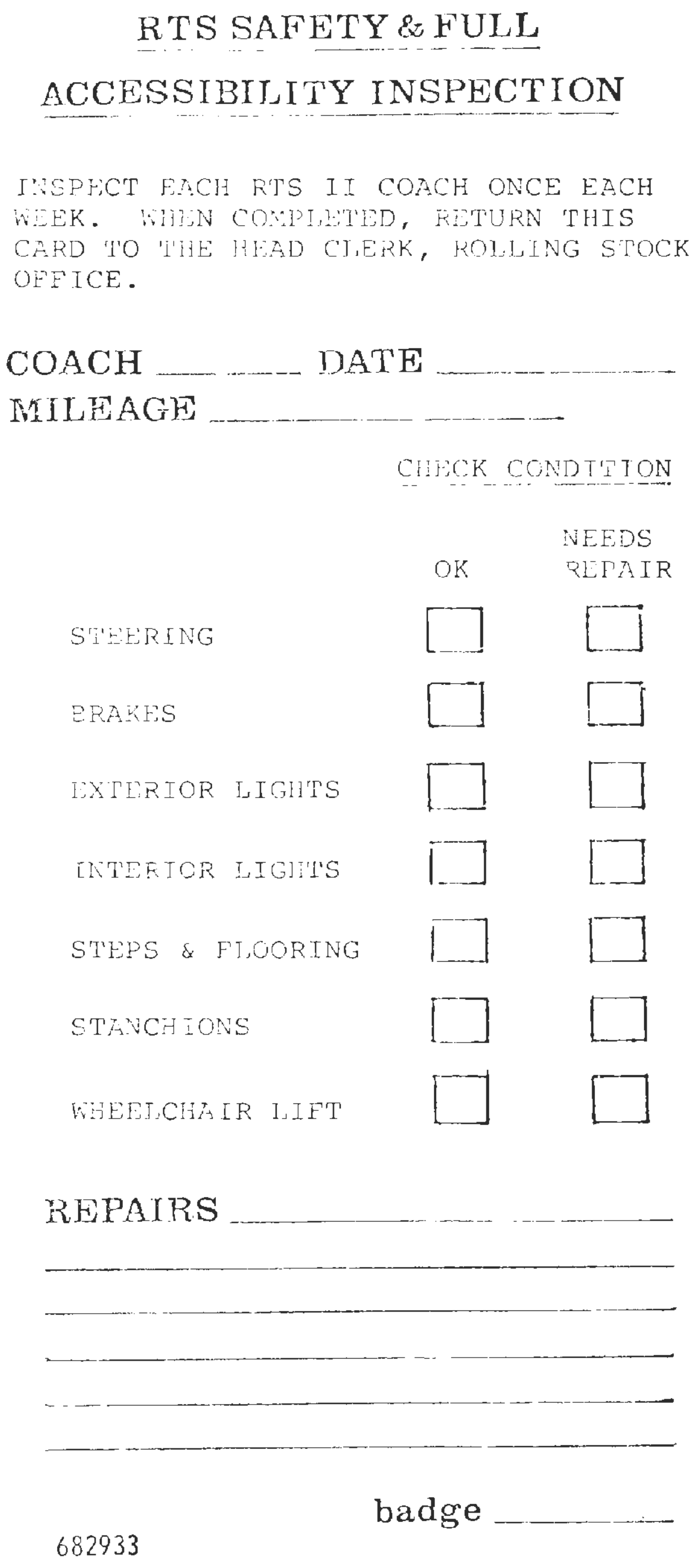
FIGURE 4.4-1: DDOT DEVELOPED DECAL AND NUMBERING SYSTEM FOR GMC LIFT

An examination of approximately 250 repairs for the Shoemaker fleet over the period of October of 1980 through April of 1981, showed that step locks, platform arms, proximity switches, and restraint cylinders seemed to be the primary maintenance concerns. It became evident that repairs at DDOT were constrained as much by spare parts availability rather than any operational requirements. Analysis of the most recent inspection records indicated that nearly half of the lifts were reported as defective and it appeared that spare parts were needed in two thirds of these. Therefore, analysis of the repair data was not pursued. The data did highlight a major problem with use of the rear doorway as a public latrine. The steam cleaning and washing needed to cure this situation exacerbated the lubrication requirements for reliable GMC lift operation.

4.4.4 Maintenance Procedures

The lift preventive maintenance is based on a weekly cycling of the lift during a brake inspection. This process was started in October of 1980 and the inspection record cards (Figure 4.4-2) were analyzed for this month and subsequent months through April of 1981 to determine lift status over this period. This involved an examination of approximately 2,000 cards and recording of lift status. Table 4.4-1 summarizes the results for each division and shows the impact of instituting the preventive maintenance procedure with a dramatic increase in lift inspections from 23 in September, to 581 in October of 1980. However, in the Spring of 1981 the situation appeared to be deteriorating again with a decrease in the number of inspections per faulty lift which reflected the lack of spare parts.

4.4.4.1 Mechanics Training - It appeared that one third of the Shoemaker mechanics had attended the GM lift course. However, selection of course attendees was based on union seniority and mechanics taking the course rarely bid for lift work at a subsequent date. DDOT was (as elsewhere) trying to move away from the old maintenance labor classifications to gain more flexibility in its work force. It was also working closely with local vocational schools to obtain a new generation of young mechanics oriented towards modern transit equipment needs.



RTS SAFETY & FULL ACCESSIBILITY INSPECTION

INSPECT EACH RTS II COACH ONCE EACH WEEK. WHEN COMPLETED, RETURN THIS CARD TO THE HEAD CLERK, ROLLING STOCK OFFICE.

COACH ____________ DATE ______________

MILEAGE ____________________

	CHECK CONDITION	
	OK	NEEDS REPAIR
STEERING	☐	☐
BRAKES	☐	☐
EXTERIOR LIGHTS	☐	☐
INTERIOR LIGHTS	☐	☐
STEPS & FLOORING	☐	☐
STANCHIONS	☐	☐
WHEELCHAIR LIFT	☐	☐

REPAIRS ______________________________

____

____

____

____

____

badge __________

682933

FIGURE 4.4-2: DDOT VEHICLE INSPECTION CARD

DIVISION/MONTH	9/80	10/80	11/80	12/80	1/81	2/81	3/81	4/81
SHOEMAKER	1	24	6	1	1	1	2	0
GILBERT	0	6	9	5	4	9	8	12
COOLIDGE	2	15	11	6	16	19	15	21
TOTAL (W/C)	3	45	26	12	21	29	25	33
TOTAL NUMBER OF INSPECTIONS	23	581	352	376	282	264	267	316
PERCENTAGE OF INSPECTIONS	7.7	12.9	13.5	31.3	13.4	9.1	10.7	9.6

TABLE 4.4-1: MONTHLY WHEELCHAIR LIFT INSPECTIONS PERFORMED BY DDOT

4.4.5 Summary

The operations at DDOT were severely constrained by financial limitations on the purchase of spare parts for the lifts, reflecting a low priority for accessible operations. The nature of the operation with 24 hour service on some routes also highlighted potential impacts on rear door lift installations.

4.5 SOUTHEASTERN MICHIGAN TRANSPORTATION AUTHORITY (SEMTA), MI

SEMTA operated 111 accessible GMC RTS-2 buses purchased over a three year period. Initial deliveries were the first lift equipped RTS-2's delivered to an operator. The distribution by model year is as follows:

1978	16 buses
1979	45 buses
1980	50 buses
TOTAL	111 buses

The site visit was conducted from June 1st through June 5th. Discussions were held with Rachel Schoener, Laurie Lysett and Peggy Green (Operations), Gerald Pachnicki and Bob Campell (Scheduling), Tom Okasinski and Kathy Gaffney (Equipment) Ted Alexander (Maintenance) and Roland St. Laurant (Maintenance-Macomb).

4.5.1 Site and System Characteristics

SEMTA provides fixed route suburban services along major arterials with its large buses and also provides community and elderly and handicapped services with a fleet of 316 small buses and vans, 65% of which are equipped with wheelchair lifts. SEMTA operates "closed door" within the City of Detroit. Also, because of a zone fare structure, the SEMTA buses use only the front door for all regular entering and exiting patrons so that the rear door is in fact a separate entry dedicated to lift users.

The SEMTA service area is part of the seventh largest metropolitan area in the U.S. with a population of approximately four million. The terrain is flat and the road conditions are generally good. The climate is essentially similar to that of Detroit and can be classed as moderately severe.

4.5.2 Operations

SEMTA had a peak fleet requirement of some 220 buses out of a total of 377 transit vehicles. Service is provided out of three divisional terminals and the distribution of the accessible buses between these was as follows:

Wayne	35 buses
Oakland	33 buses
Macomb	43 buses
TOTAL	111 buses

The accessible fleet is used on a limited number of routes so that the level of accessibility provided is high.

Only the Macomb division had extensive experience with all three model year coaches and their accessible fleet was divided as follows:

1978	11 buses
1979	15 buses
1980	17 buses
TOTAL	43 buses

4.5.2.1 Ridership and Road Calls - The system had experienced low ridership with 80% occurring in the Macomb division which was averaging about 40 trips per month. Due to this concentration of ridership, most of the site visit activities were centered upon the Macomb operation. Overall, despite the low ridership, the quality of service had been good. During 1980, the Macomb operation received ten lift related road calls out of 350 calls in all. On six of these occasions, a replacement bus was sent. Delays were only incurred on three occasions and totalled 2.5 hours out of 115 hours for all calls over the same period. During this period, some 500 wheelchair trips were made so that the failure rate per trip was only 0.2%. For the first five months of 1981, only four road calls have occurred (three during February) with only one bus change required and a total of 25 minutes of delay. Total calls and delays during this period were 175 and 62 hours 22 minutes respectively.

4.5.2.2 Driver Training - These activities paralleled those of the DDOT operation but SEMTA did not adopt their revised decal and numbered controls.

4.5.3 Lift Experience

For internal purposes, the three divisional terminals had collected data on lift repairs covering the six months of November of 1980 through April of 1981. The data formats varied among the divisions, but the data may be summarized as follows:

	TERMINAL		
	Wayne	Oakland	Macomb
Number of Accessible Coaches	35	33	43
Six Month Ridership	25	40 (est.)	237
Number of Lift Repairs	12	34	34
Repair Hours	8.0	23.0	101.5
Number of Parts Used	13	7	51
Part Costs	N/A	$457.15	N/A

The data submitted by Macomb division for repairs over the six months, showed 51 repairs; however, it appeared from inspections of some of the charge-out sheets that in a number of cases multiple parts were needed to complete one repair. Grouping parts used on the same bus where the reason for repair is similar produced a minimum estimate of 34 repairs as shown above.

Since 80% of the ridership was reported by Macomb and this division was also the only one with extensive experience of all three model years it became the focus of the SEMTA site visit and data analysis. Therefore, unless otherwise noted, the following data relates to the Macomb division operations.

The intensity of use of the fleet has declined as more vehicles have been added while ridership has remained virtually constant. The division had kept a log of repairs for 1978 and 1979 and part way into 1980, plus the summary of the latest six months based on parts consumption. A major effort was made to fill in the gaps through a review of the drivers write-up cards, the warranty records, and parts charge out sheets. This involved sifting through several thousands of the write-up cards provided from storage by the SEMTA division personnel to extract those of the lift equipped fleet and then to find and record instances of reported wheelchair defects and repairs. The number of repairs by bus fleet for 1980 to May of 1981

(Figure 4.5-1) demonstrated a variable level of monthly repairs, which seemed to reflect the overall ridership reported. The cumulative records show a steady rate of repairs for the whole fleet which averages ten repairs a month (Figure 4.5-2). A review of the figures for the different year models shows that the 1979 and 1980 buses had 20-30% fewer repairs per bus than the 1978 vehicles although the difference narrowed in 1981 (Figure 4.5-3). Initially, the 1979 buses seemed to have had a higher repair rate than the 1980 models, but the first five months of 1981 shows no difference between the 1979 and 1980 model coaches.

It must be cautioned that many of the repairs were corrective actions rather than repairs of failed components, therefore, the records required a fair degree of interpretation. For instance, many of the lift failures were related to the step locks failing to disengage. These were variously reported by different mechanics as "frozen," "stuck," and a need to "free-up." Where it appeared that the primary needs were just for lubrication, then such incidents were not counted as repairs. Similarly, in some instances the simple notation of "repaired lift" was used with no other diagnostic information or evidence of parts use. These instances were also not counted since it was felt that the probability was that the primary effort needed was lubrication. The net result was an overall repair rate of ten per month, but with fluctuations from a high of over 20 to a low of one repair per month.

A review of the spare parts consumption for one year through (June 1980-June 1981) based on SEMTA's computer printout indicates that a small number of hydraulic and electrical components made up the majority of spare parts for lifts. The records included nearly 80 lift-related items with a total cost of nearly $36,500. Table 4.5-1 lists the eleven items whose total costs exceeded $500. The list includes high cost items of which relatively few are used and high volume items of lower unit cost. Table 4.5.-1 also indicated that replacement of some of the higher priced items had dropped substantially during the latter part of the reporting period. These parts were primarily hydraulic cylinders and the reduction in replacement rates reflected the increasing level of experience with the lift particularly in avoiding overstressing by jacking the bus with the lift. The monthly consumption patterns also varied considerably. Table 4.5-2 shows the total usage for the two months of April and May of 1981. Despite the wage variation, a similar pattern of 20% to 25% of the parts accounting for 75% to 80% of the materials costs emerge.

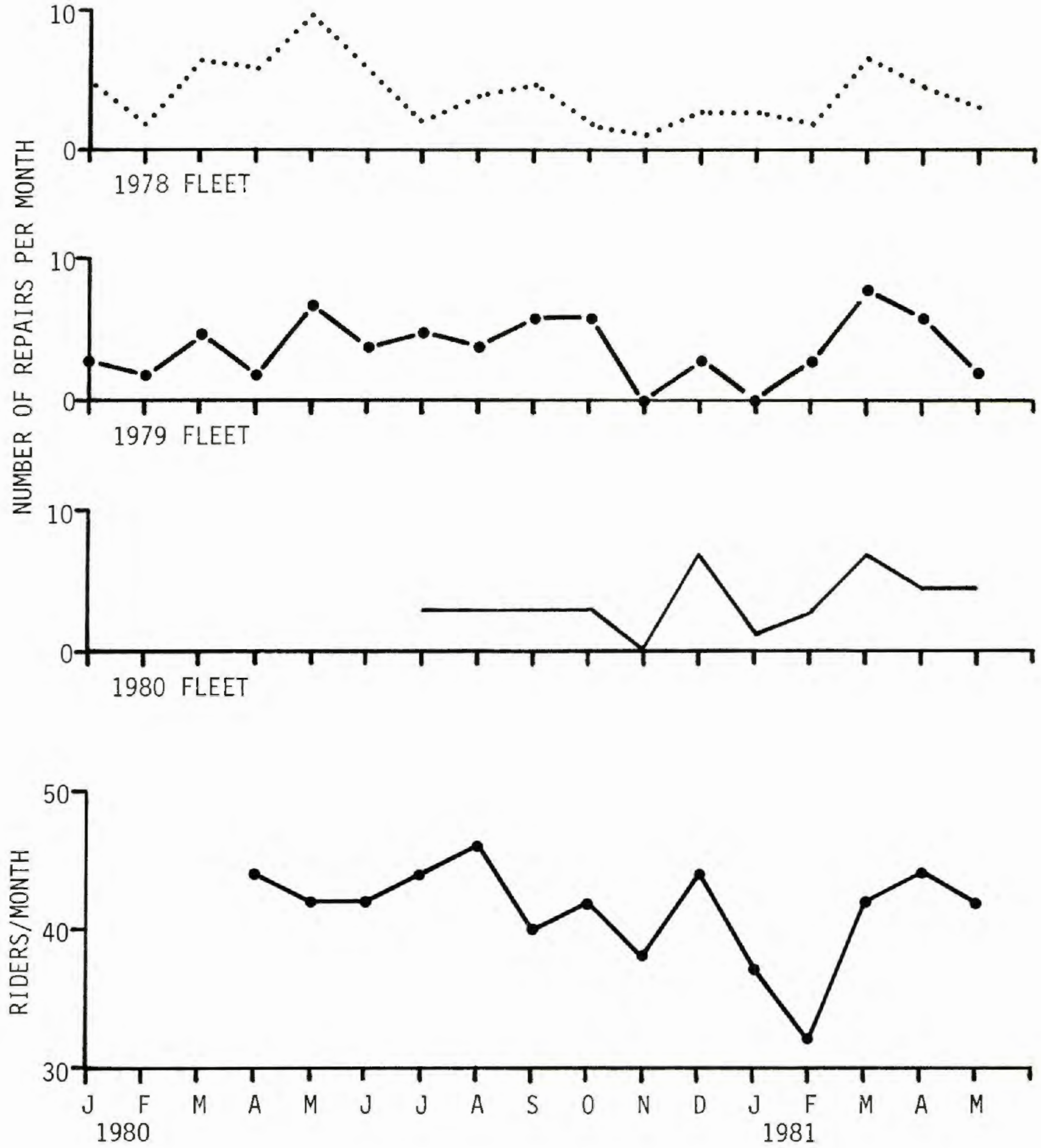


FIGURE 4.5-1: NUMBER OF REPAIRS BY BUS FLEET AND RIDERSHIP AT SEMTA-MACOMB

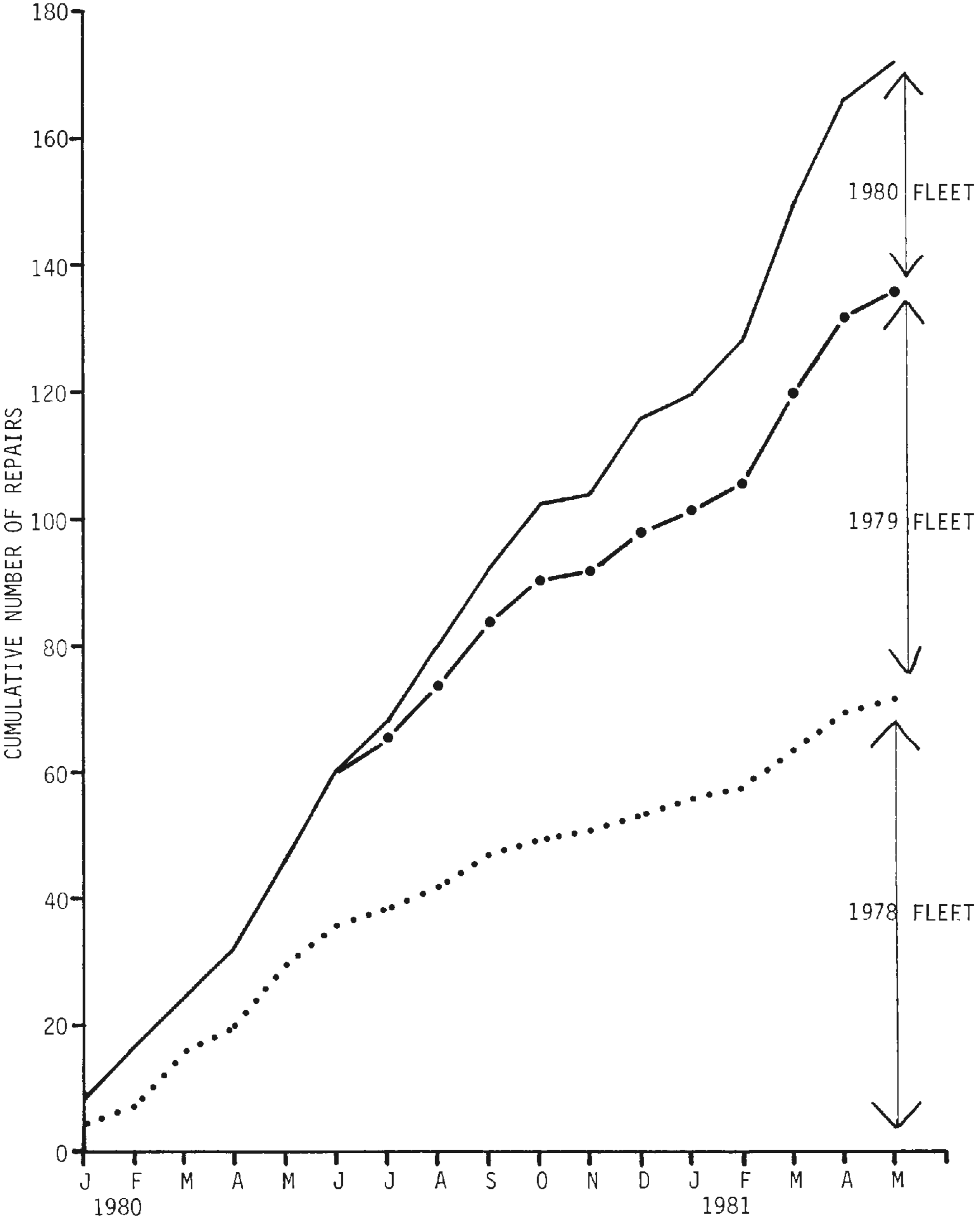


FIGURE 4.5-2: CUMULATIVE LIFT REPAIRS AT SEMTA-MACOMB

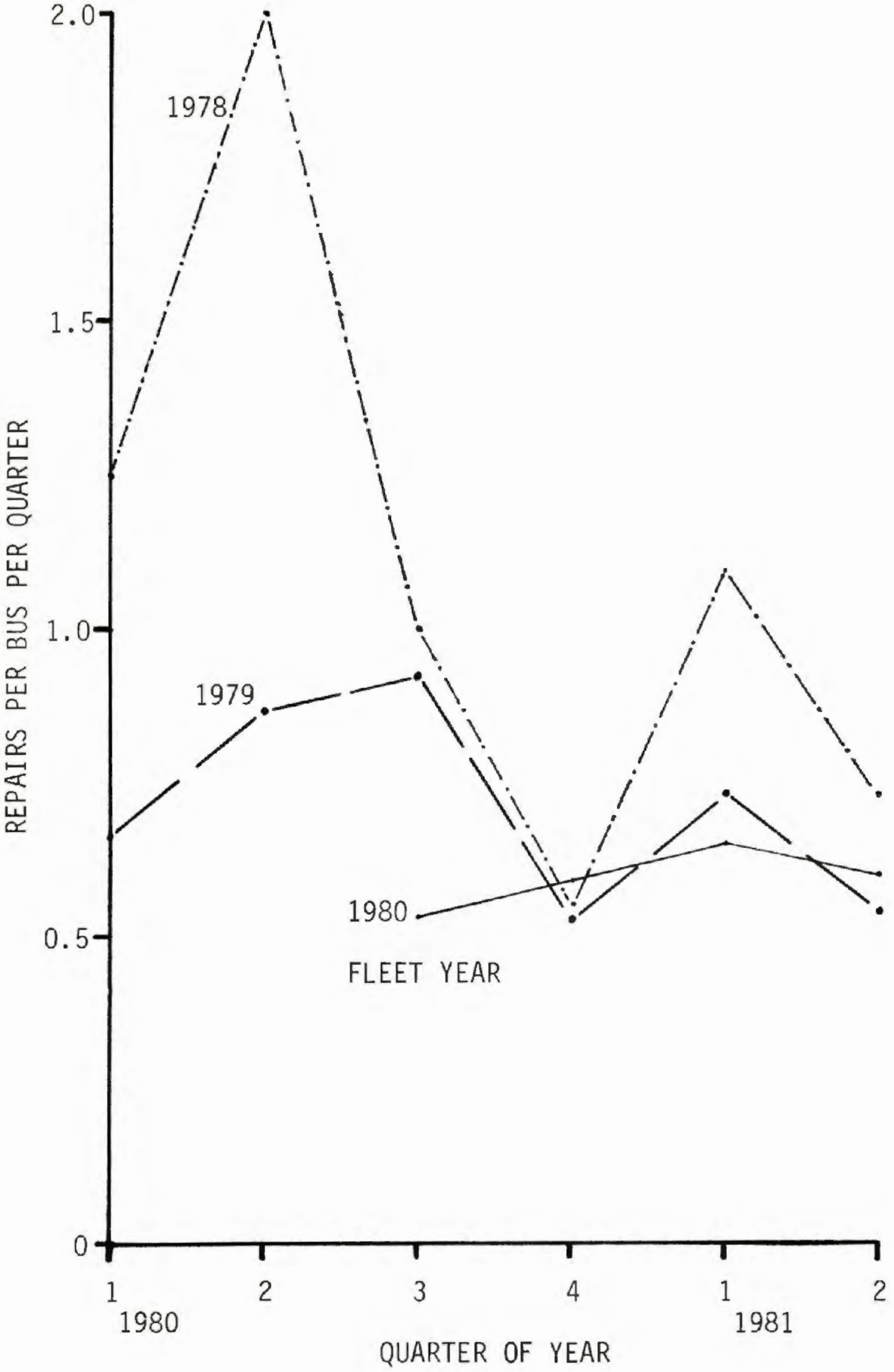


FIGURE 4.5-3: RELATIVE FLEET REPAIR RATES AT SEMTA-MACOMB

Part Number	Component	Amount Used	Unit Price ($)	Total Cost ($)	Amount Used Last Month	Prior Months With No Usage
2039826	Switch	43	199.37	8,572.91	7	0
" 6953	Cont. Box	8	754.40	6,035.20	2	0
" 5595	Cylinder	24	189.96	4,559.04	7	0
" 6778	Switch	12	232.26	2,787.12	0	5
" 5597	Valve	2	1,028.30	2,056.60	0	4
" 5594	Cylinder	5	323.15	1,615.75	0	4
" 6167	Cylinder	5	323.15	1,615.75	0	7
" 5599	Cylinder	23	60.54	1,393.42	1	0
" 4558	Cylinder	15	44.13	661.95	4	0
" 7241	Stud	33	18.13	598.29	1	0
" 6578	Switch	4	140.20	560.80	1	0

TABLE 4.5-1: MAJOR LIFT REPAIR PARTS USED AT SEMTA FROM THE COMPUTERIZED INVENTORY RECORD

Part Number	Component	Amount Used	Unit Price ($)	Total Cost ($)
April 1981				
2004573	End	4	17.29	69.16
2018979	Valve	3	15.89	47.67
2034558	Cylinder	3	44.13	132.39
" 5215	Bolt	1	68.00	68.00
" 5216	Bolt	1	68.00	68.00
" 5446	Sign	1	36.00	36.00
" 5595	Cylinder	2	189.96	379.92
" 5602	Arm	1	11.47	11.47
" 6864	Switch	1	18.87	18.87
" 6953	Box	1	754.40	754.40
" 7237	Rod Assby	5	28.50	142.50
" 7241	Stud	2	18.13	36.26
" 7243	Bolt	5	13.95	69.75
" 7247	Cable	3	16.56	49.68
" 7248	Clevis	1	29.33	29.33
" 7250	Bearing	2	3.07	6.14
" 9826	Switch	3	199.37	598.11
2056567	Shield	5	30.00	150.00
" 6685	Bracket	20	3.67	73.40
" 8532	Bolt	4	13.19	52.76
2395640	Screw	1	0.10	0.10
9420821	Nut	9	0.04	0.36
	TOTALS	78		2,794.27
May 1981				
2016640	Spring	1	1.84	1.84
" 8979	Valve	2	15.89	31.78
2034558	Cylinder	4	44.13	176.52
" 5595	Cylinder	6	189.96	1,139.76
" 5599	Cylinder	1	60.54	60.54
" 5600	Cylinder	1	29.52	29.52
" 6629	Valve	1	230.82	230.82
" 6864	Switch	1	18.87	18.87
" 6953	Box	2	754.40	1,508.80
" 7247	Cable	3	16.56	49.68
" 7248	Clevis	1	29.33	29.33
" 9324	Cover	1	28.48	28.48
" 9826	Switch	7	199.37	1,395.59
2056019	Hose	2	64.52	129.04
" 6567	Shield	2	30.00	60.00
" 6685	Bracket	8	3.67	29.36
2060178	Cartridge	1	131.53	131.53
9420821	Nut	9	0.04	0.36
	TOTALS	53		5,051.82

TABLE 4.5-2: COMPARISON OF LIFT PARTS USED OVER TWO CONSECUTIVE MONTHS AT SEMTA

4.5.4 Maintenance

SEMTA/Macomb has 24 mechanics for a divisional fleet of 162 buses (121 transit and 41 E/H small buses). Lift servicing consists of a nightly cycling by the graveyard shift and a SEMTA-developed 12,000 mile inspection procedure (Figure 4.5-4). These procedures appear to have been sufficient to provide the necessary accessible fleet availability (33 buses out of 43) to meet schedule requirements. This is supported by an analysis of the daily bus status sheets for March through May of 1981 in which bus status was allocated under the following headings:

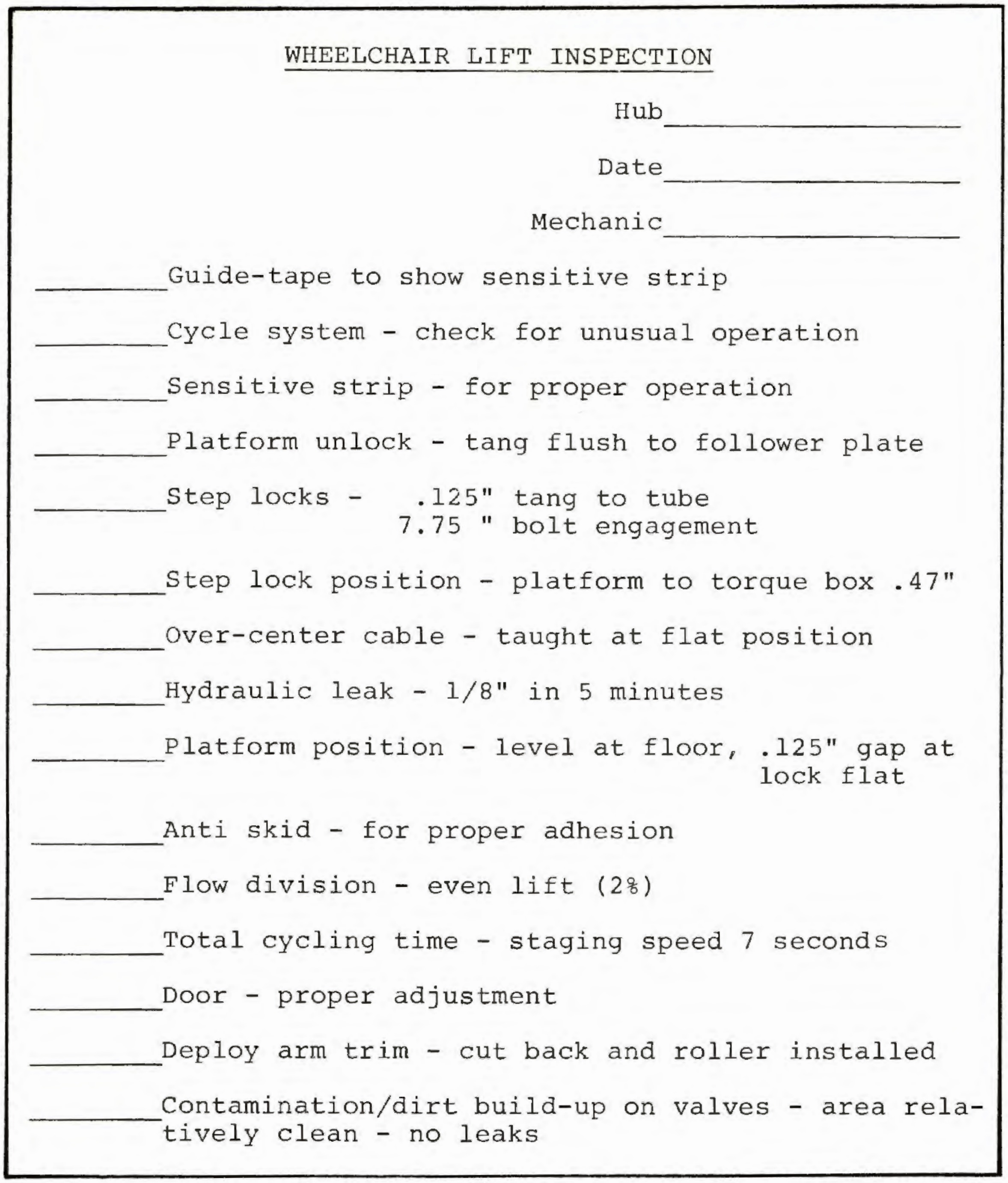
OK: Lift found to be in working order.
NC: Not checked, i.e. no entry found against that bus number.
BD: Bus down, i.e. bus in for other repairs. Lift status not counted
BAD: Lift reported as defective.
REP: Lift repaired and available for next day's work.

Figure 4.5-5 illustrates daily fluctuations in the number of known working (OK) and bad (BAD) lift categories many lift repairs were minor and were corrected during the next day's work shift.

4.5.4.1 Mechanic Training - All of the division's mechanics have attended the GMC one day course on lift maintenance which is provided by GMC at their Technical Center in nearby Warren, Michigan.

4.5.5 Summary

Wheelchair trips at SEMTA were concentrated on routes from one division. Despite the relatively low level of ridership, the division was able to maintain reliable service by a simple procedure of overnight checks for lift function.



WHEELCHAIR LIFT INSPECTION

Hub ____________________

Date ____________________

Mechanic ____________________

________ Guide-tape to show sensitive strip

________ Cycle system - check for unusual operation

________ Sensitive strip - for proper operation

________ Platform unlock - tang flush to follower plate

________ Step locks - .125" tang to tube
7.75 " bolt engagement

________ Step lock position - platform to torque box .47"

________ Over-center cable - taught at flat position

________ Hydraulic leak - 1/8" in 5 minutes

________ Platform position - level at floor, .125" gap at lock flat

________ Anti skid - for proper adhesion

________ Flow division - even lift (2%)

________ Total cycling time - staging speed 7 seconds

________ Door - proper adjustment

________ Deploy arm trim - cut back and roller installed

________ Contamination/dirt build-up on valves - area relatively clean - no leaks

FIGURE 4.5-4: SEMTA 12,000 MILE LIFT INSPECTION PROCEDURE

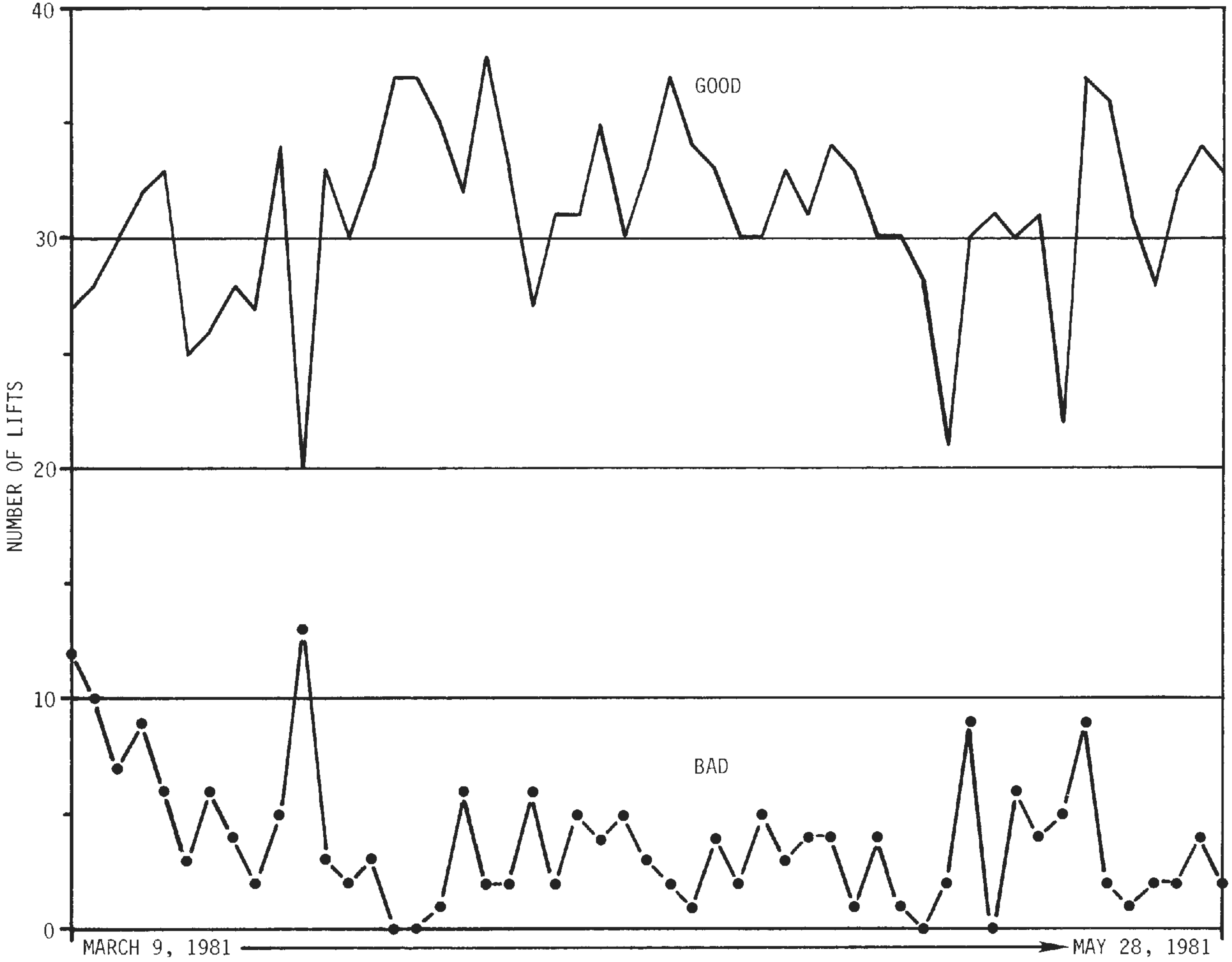


FIGURE 4.5-5: DAILY VARIATION OF "GOOD" AND "BAD" LIFTS AT SEMTA-MACOMB

4.6 EUGENE (LANE COUNTY MASS TRANSIT DISTRICT), OR

Lane County Mass Transit District (LTD) had 18 GMC (Canada) "new look" buses which had been retrofitted with lifts by Lift-U prior to delivery in January through March of 1981. The site was visited on two occasions, September 13-14 and November 15-16 of 1981. Discussions were held with Leon Skiles, Service Analyst, Steven Dallas, Operation Manager, and Bill Clyne, Shop Foreman.

4.6.1 Site and System Characteristics

LTD serves the communities of Eugene and Springfield on the upper reaches of the Willamette Valley. Except for outlying areas, the terrain is essentially flat and road conditions are good. The climate is moderate with an annual average of eight inches (20.3cm) of frozen precipitation and 32 inches (20.3 cm) of rain. Temperature range is from an average minimum of 32°F (0°C) in January to an average maximum of 82°F (28°C) in July.

LTD provides fixed route services on 30 routes using a pulse system centered upon an extensive pedestrian mall area in downtown Eugene. The total peak fleet requirement is 50 buses. LTD does not have a severe peak load; ridership is highly dependent upon the students at the University of Oregon. During the site visits, a major revision of the routes and schedules had been initiated and accessible service had been expanded from eight to 14 routes. These routes use 15 of the accessible buses and represent 38% of the scheduled service hours and provide over 60% of the overall patronage.

In addition to the regular fixed routes LTD operates a handicapped and frail elderly demand responsive service which provides over 20,000 rides annually.

4.6.1.1 Ridership and Road Calls - The system has experienced high ridership from the outset and this has increased substantially with the service expansion as shown by the following figures for the first seven months of operation in 1981.

Month	Lift Passengers	System Ridership	Lift/System (%)
April	221	276,055	0.07
May	257	251,227	
June	287	228,848	0.1
July	285	211,255	
August	293	196,866	0.15
September	450	204,514	
October	544	280,754	0.19

The service has also been improving in reliability as indicated in the following data on road calls for the accessible buses.

Month	Road Calls-Lift	Road Calls Total	Lift/Total (%)	Riders/Call
April	6	42	14.3	37
May	7	52	13.5	37
June	12	53	22.7	24
July	9	52	17.3	32
August	3	40	7.5	98
September	8	44	17.0	57
October	9	61	15.0	60

Apart from the expected impacts of breaking in new equipment and the steady growth in ridership, the increased road calls during June and July were, in part, attributable to driver unfamiliarity with the equipment by new drivers following a run pick in early June. The figures for September include one case of a driver deploying the lift at an unauthorized location and getting it stuck on a curb and those for October include two cases of handrail repairs. The figures for the first 13 days of November indicated some further improvement in reliability was likely.

4.6.1.2 Driver Training - All LTD drivers participated in a four hour driver training program consisting of:

- 1/2 hour orientation on property
- 1 1/2 hour movie presentations (e.g. SCRTD's New Mobility)

- o 2 hours actual on street bus use
- o The class sizes for the first two items were four drivers with two instructors, but for the road driving two drivers were paired with one instructor. Volunteers from an Advisory Committee participated in all aspects of this training.

4.6.2 Lift Experience

The buses were still under warranty at the beginning of November of 1981. Two buses had exceeded 50,000 miles, but the fleet average was about 39,000 miles. Lift-U policy is to provide 12 months of warranty regardless of bus mileage so that the lifts would be covered for several more months in most cases. The recent months work orders at LTD had not been fully processed and recorded in the individual bus histories. The records for July were the most readily accessible and these were examined and recorded. It should be noted that since the lifts were still under warranty the major parts used were generally returned to Lift-U for credit or replacement. This may account for the lack of records in some cases.

The consumption of parts taken from the inventory cards did give a clear picture of the major lift repairs being undertaken at LTD. Table 4.6-1 shows the consumption from April through October of 1981 involving 108 items covering 23 different parts. Also shown is the number of parts per month and the value per month. The number of parts had declined from a high of 27 in April to a relatively steady average number of 13-14 in the ensuing months. Similarly, the value of parts used has remained relatively constant at about $1,050 with the exceptions of April and October where the figure is nearer to $1,700.

Table 4.6-2 shows the ten largest items by dollar value and also their ranking by numbers used. It is readily apparent that only a few parts are major value items with the first three contributing nearly 90% of the total. Of these, only one, the drive nut, is truly consumed due to wear. Replacement of the screw motor and lift cylinders is due to leakage appearing at joints. If these parts were not under warranty, they would be rebuilt and returned to stock or possibly a higher grade component would be introduced. In-house rebuild and replace costs are estimated by Lift-U to be $25 and $17 respectively for the motor and cylinder.

Number	Part	Amount of Parts/Cost of Parts							
		April	May	June	July	August	September	October	Total
715- 0003	Handrail							1/$ 74.50	1/$ 74.50
0004	Limit Swtch	1/$ 64.50	1/$ 64.50	2/$ 129.00					4/ 258.00
0006	Drive Nut	2/ 164.06	3/ 246.09	3/ 246.09	2/$ 164.06	6/$ 492.18	8/$ 656.24	3/ 246.09	27/ 2,214.81
0007	Sol. Valve							2/ 249.00	2/ 249.00
0010	6lk. Chain	2/ 21.60						2/ 21.60	4/ 43.20
0011	Bearing	2/ 1.60					1/ 0.80		3/ 2.40
0011A	Bearing	10/ 14.60	2/ 2.28	1/ 1.74	8/ 13.84				21/ 32.46
0012	Switch						1/ 9.88		1/ 9.88
0013A	Stow Swtch		2/ 19.76	1/ 9.88					3/ 29.64
0014	Flow Con.V	1/ 13.65					1/ 13.65		2/ 27.30
0016	Rod Toe Pte					1/ 1.74			1/ 1.74
0018	Main Cylin.	2/ 355.00		1/ 177.50	3/ 532.50	3/ 532.50		2/ 355.00	11/ 1,952.50
0019	Divert.Vlv.			1/ 25.35					1/ 25.35
0020	Diode	2/ 8.00						1/ 4.00	3/ 12.00
0022	Spring	1/ 1.00							1/ 1.00
0023	Screw Motor	3/ 1,057.50	2/ 705.00	1/ 352.50	1/ 352.50		1/ 352.50	2/ 705.00	10/ 3,525.00
0024	Dr.Edge Bsh	1/ 6.00	2/ 12.00	1/ 6.00					4/ 24.00
0025	Off Switch		1/ 4.50	1/ 4.50					2/ 9.00
0026	Relay					1/ 8.00			1/ 8.00
0028	Limit Swtch			2/ 129.00					2/ 129.00
0029	Fitting				1/ 1.20				1/ 1.20
0032	Filter Elm.							2/ 14.40	2/ 14.40
0033	Warn.Beeper							1/ 13.34	1/ 13.34
	TOTALS	27/$1,707.51	13/$1,054.13	14/$1,081.56	15/$1,064.10	11/$1,034.42	12/$1,033.07	16/$1,682.93	108/$8,657.72

TABLE 4.6-1: LIFT PARTS USED AT LTD FOR APRIL-OCTOBER 1981 FROM INVENTORY RECORDS

Lift Part	Amount Used	Dollar Value	Rank by Amount Used
Lift Screw Motor	10	$3,525.00	4th
Drive Nut	27	2,214.81	1st
Main Cylinder	11	1,952.50	3rd
Limit Switch	4	258.00	5th equal
Solenoid Valve	2	249.00	11th equal
Limit Switch	2	129.00	11th equal
6 Link Chain	4	43.20	5th equal
Bearing	21	32.45	2nd
Stow Switch	3	29.64	8th equal
Flow Control Valve	2	27.30	11th equal

TABLE 4.6-2: HIGHEST COST LIFT REPAIR PARTS USED AT LTD OVER SEVEN MONTHS

The labor hours associated with lift repairs at LTD could only be approximated. The figures for July indicated that after subtracting out the hours for preventive maintenance and related adjustments, other repairs totalled approximately 140 hours. Based on the components used and some specific hours for repairs from July it would appear that this figure is probably representative of September and October.

4.6.3 Lift Maintenance

LTD has developed a 45 point inspection check list (Figure 4.6-1) for their lift maintenance program. This check is done weekly during the weekend reduced service period and usually covered most of the buses. It is estimated by LTD to take one hour. These inspection records were examined for the period April 4 through October 31, 1981. In very few instances was trouble indicated that would immediately warrant a lift being removed from service although many of them carried comments of a cautionary nature regarding potential leakage, wear, and adjustment problems. In many cases, the minor repairs indicated were carried out on the spot. Figure 4.6-2 shows in matrix form the results of this review with the following notation:

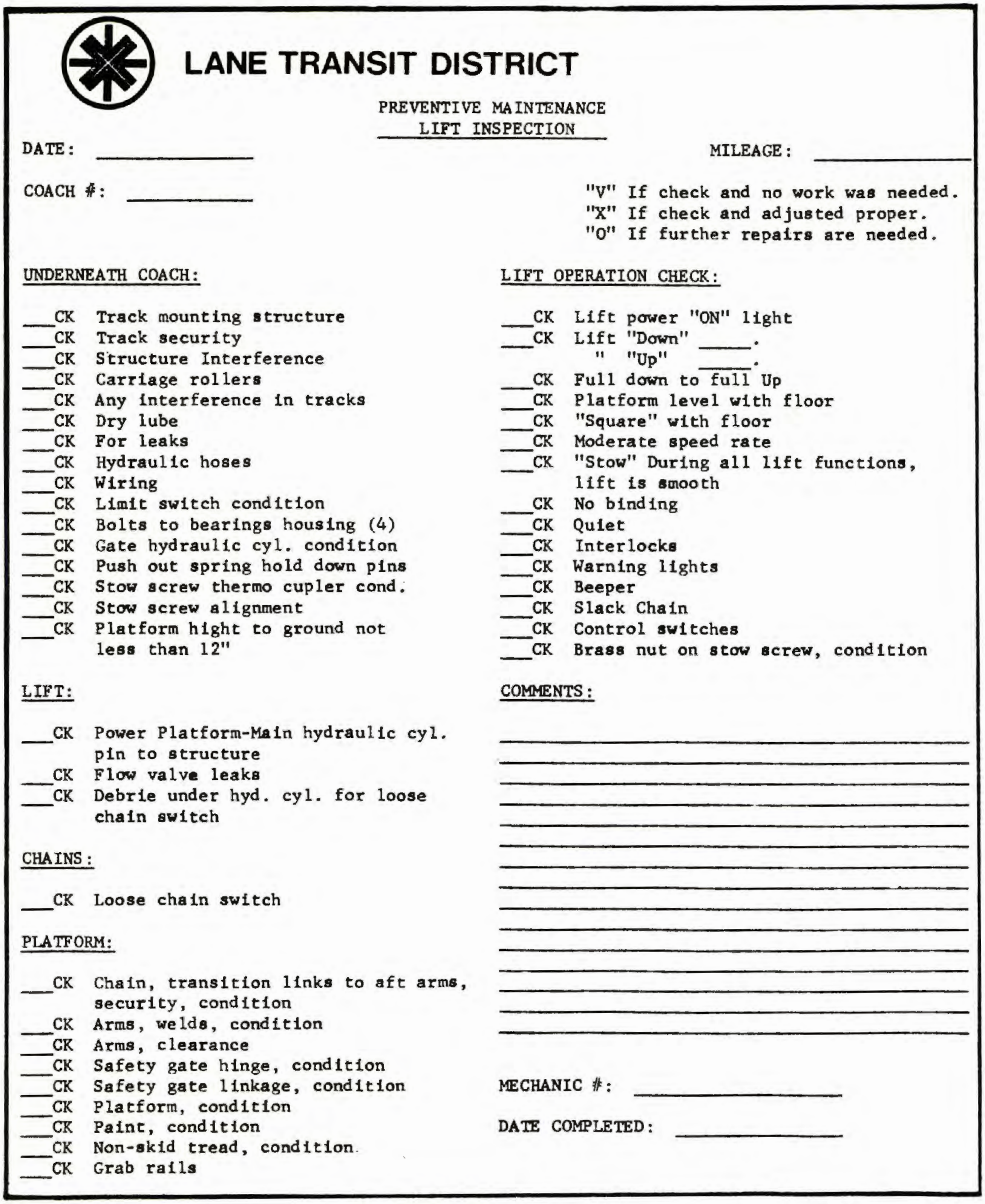
r = lift repair component replaced

c = comments regarding minor repairs, adjustments, and pending problems

= no defects found

No entry = no record, bus not inspected.

As can be seen, the incidence of buses with lifts classified under "r" is very small. This did not, represent the total of repairs since most of these are scheduled for the normal workday shifts. Overall the number of buses inspected, with no defects found, has improved since the initial months of operations and appears to have stabilized at approximately 50% of the buses inspected. The initial results of the service expansion did not appear to have had a major impact on the inspection histories. Comparing the three months of May, August, and October all of which had five weekends the following table shows little change between August and October despite an 85% ridership increase and both are significantly better than May.



LANE TRANSIT DISTRICT

PREVENTIVE MAINTENANCE
LIFT INSPECTION

DATE: ____________

MILEAGE: ____________

COACH #: ____________

"V" If check and no work was needed.
"X" If check and adjusted proper.
"O" If further repairs are needed.

UNDERNEATH COACH:

- ___ CK Track mounting structure
- ___ CK Track security
- ___ CK Structure Interference
- ___ CK Carriage rollers
- ___ CK Any interference in tracks
- ___ CK Dry lube
- ___ CK For leaks
- ___ CK Hydraulic hoses
- ___ CK Wiring
- ___ CK Limit switch condition
- ___ CK Bolts to bearings housing (4)
- ___ CK Gate hydraulic cyl. condition
- ___ CK Push out spring hold down pins
- ___ CK Stow screw thermo cupler cond.
- ___ CK Stow screw alignment
- ___ CK Platform hight to ground not less than 12"

LIFT:

- ___ CK Power Platform-Main hydraulic cyl. pin to structure
- ___ CK Flow valve leaks
- ___ CK Debrie under hyd. cyl. for loose chain switch

CHAINS:

- ___ CK Loose chain switch

PLATFORM:

- ___ CK Chain, transition links to aft arms, security, condition
- ___ CK Arms, welds, condition
- ___ CK Arms, clearance
- ___ CK Safety gate hinge, condition
- ___ CK Safety gate linkage, condition
- ___ CK Platform, condition
- ___ CK Paint, condition
- ___ CK Non-skid tread, condition
- ___ CK Grab rails

LIFT OPERATION CHECK:

- ___ CK Lift power "ON" light
- ___ CK Lift "Down" _____.
  " "Up" _____.
- ___ CK Full down to full Up
- ___ CK Platform level with floor
- ___ CK "Square" with floor
- ___ CK Moderate speed rate
- ___ CK "Stow" During all lift functions, lift is smooth
- ___ CK No binding
- ___ CK Quiet
- ___ CK Interlocks
- ___ CK Warning lights
- ___ CK Beeper
- ___ CK Slack Chain
- ___ CK Control switches
- ___ CK Brass nut on stow screw, condition

COMMENTS:

MECHANIC #: ____________

DATE COMPLETED: ____________

FIGURE 4.6-1: LTD PREVENTIVE MAINTENANCE INSPECTION FOR LIFT-U LIFT

Month	April				May					June				July*				August					September				October				
Bus/Sunday	4	11	18	25	2	9	16	23	30	6	13	20	27	4	11	18	25	1	8	15	22	29	5	12	19	26	3	10	17	24	31
701	√	c	c	c	c	c	√	√	c	√	c	c	√	√					√	r	√	√	√	√	√		√	√	r	c	√
702		c	√	√	c	c	√	c	c	√	c	√	√	√	√	√	c	c	c	c	r	c		√	√			√		r	√
703	c	c	c	c	c	√	c	c	√	√	c	c	c	c	√		√	c	c	r	√	c	c	c	√	c	c	√	c	√	√
704		c	c	c	r	c	√	c	c	c	c	√	c	c				c	√	c	c	c	r	c	c	r	r	c	√	√	c
705		c	c	r		c	c	c	√	√	c	√	c	√				c	c		c		c	c	c		c	√	c	c	c
706	c	c	c	c	c	√	√	c	c	c	c	c	c				c	c	c	c	√	c		√	c		c	c	c	r	c
707	c	c	c	c	c	c	√	c	c	√	√	c		√		c	√	√	c	√	√	√		c	√	r	√	√	√	c	√
708	√	c	c	c			c	c	c	c	√	√	√	√		√	√	√	√	√	√	√			c	√	c	√	√	√	c
709		c	c	√	c	c	√	c	c	c	c	√	c	√	√			c	c	c	√	c		c	c		r	√	c	c	
710	√	c	c	c	c	c	c	√	√	c	√	c	c	√			c	√	√	√	c	√		c	√		r	√	√	√	√
711		c	c	√	√	√	√	c	√	c	c	c	c	c			c	c	√	c	√			c	√	c		√	c	√	r
712		c	√	c	c	√	√	√	√	√	c	c	√	c			c	c	√	√	√	√	c	√	c		c	√	c	√	c
713	c	c	c	√	c	c	c	c	c	√	√	√	√				√	√	√	√	√	√		√	√	√	√	√	√	c	√
714	c	c	c	c	c	c	√	c	c	c	√	c	√				c	c	√	√	√		c	√	√	√	c	c	√	√	√
715		c	c	c	c	c	√	c	c	√	c	c	c		c	c	√	c	c	c	c	√		√	√	√	c	c	c	√	√
716	√	c	√	√	√	c	√	c	√	c	√	√	√	√			√	c	√	√	√	c		√	√	c	c	√	c	c	√
717	c	c	c	c	√	c	√	√	√	√	c	√	c			c	√	c	√	√	√	c			c	√	r	c	√	c	c
718	√	c	c	c	c	√	√	c	√	c	c	c	c	√		√	√	√	√	√	r	√		√	√	√	√	√	√	√	c
#/Inspected	11	18	18	18	16	17	18	18	18	18	18	18	17	13	4	6	14	17	18	17	18	15	6	16	18	11	16	18	17	18	18
#/√	5	0	3	5	3	5	13	4	8	9	6	8	7	9	3	3	8	5	11	9	12	8	1	9	11	6	4	13	8	9	9
% √/Insp.	45	0	16	27	19	29	72	22	44	50	33	44	41	70	75	50	57	29	61	53	67	57	17	56	61	55	25	72	47	50	50

*The repair records for July indicate that up to ten more inspections were performed than were found from the filed inspection sheets.

FIGURE 4.6-1: LTD LIFT INSPECTION HISTORY FOR APRIL THROUGH OCTOBER 1981 BY BUS NUMBER

Month	Total Inspections	No Defects Found	No Defects - %	Ridership
May	84	33	38	257
August	85	45	53	293
October	87	43	49	544

An analysis of the repair records for July indicated that the inspections and asociated lubrication, adjustment, and minor repair work averaged two hours per bus which is double the estimated time for the inspection process itself.

4.6.3.1 Mechanic Training - No special training has been given to the maintenance staff. They have developed procedures and maintenance aids on their own, including a platform rail alignment jig and a remote control console that allows the lift to be operated from the underside of the bus when it is on a servicing hoist.

4.6.4 Summary

LTD has a successful operation with high ridership reflecting a positive approach by the community and all levels of LTD management and personnel. The maintenance levels appear high in relation to other users of the Lift-U reflecting the newness of the operation and the high level of lift use.

4.7 GRAND RAPIDS AREA TRANSIT AUTHORITY (GRATA), MI

GRATA operated fifteen GFC 870 coaches with EEC lifts, and was also retrofitting GMC "new look" coaches. All these vehicles had or would have a model of the EEC lift. The visit to GRATA was decided upon after the initial site selection process to provide some further insight into the GFC 870/EEC installation. GRATA only provided accessible fixed route service from April through December of 1980, after which time the buses were withdrawn from service because of the 870's structural problems. The site was visited on June 12, 1981 and discussions were held with Don Edmondson, Executive Director, Charles Creek, Operations Manager, and Daniel Daynon and John Meimiller, - Lift Mechanics. GRATA had provided a substantial amount of data on their lift repairs prior to the visit which greatly expedited the site assessment process.

4.7.1 Site and System Characteristics

GRATA had a fleet requirement for 54 buses and during the accessible service period scheduled ten out of its 15 lift equipped vehicles for service on a limited number of routes. GRATA also operated an extensive demand responsive elderly and handicapped service. The buses were stored under cover in a modern facility, but operate in a severe winter climate. Average annual winter precipitation is 78 inches (198 cm) and rainfall is 25 inches (6.35 cm). Average January minimum and July maximum temperatures are 16°F (-9°C) and 83°F (28°C) respectively.

4.7.1.1 Ridership and Road Calls - Ridership during the accessible service period was low, averaging ten to 15 trips per month. Overall service reliability was good with only six lift related road calls during the nine months service period which represented only 5% of all the road calls on the GFC 870 vehicles. This good record can be attributed to GRATA's conscientious effort to keep the lifts in working order.

4.7.1.2 Driver Training and Procedures - A full eight hours training on the lift was given to the operators, and they required to cycle the lifts before leaving the garage (generally observed by a supervisor). In addition, a numbered operating sequence for the lift with the procedure mounted on a decal on the farebox and corresponding numbers placed on the control box was developed to aid the drivers memory.

4.7.2 Lift Experience

Figure 4.7-1 shows the trends in repair hours, preventive maintenance hours, the number of repairs and road calls, and the hours per repair during the period of accessible service. The favorable trends undoubtedly reflect the overall learning process and the establishment of the maintenance program. The major problems encountered by GRATA may be summarized as:

1) A substantial number of initial adjustments were required on the coaches as delivered.

2) Need to improve the sealing of underfloor components particularly the control box - EEC has been critical of the placement of this item by Flxible in the 870.

3) Leakage of the seals of the barrier actuating cylinder - EEC has changed the design of this component.

4) Breakage and wear of the pivots and pivot pins on the barrier actuator connector - cured by introducing larger diameter washers to prevent the end of the barrier actuator cylinder from contacting the ground, plus better quality pins - EEC has also modified this item.

5) Sticking of the platform level sensor particularly in cold weatherr - GRATA campaigned their fleet to free up and lube the pendulums.

6) Wires pulling off due to bad routing.

7) Excessive pressure in the power steering pump circuits leading to hose failure.

8) Some faulty relays and hydraulic valves.

GRATA added a warning to the manually operated emergency system to remind operators that the manual control must be returned to neutral after use, or the system will spill hydraulic fluid the next time it is activated. Also as a result of experience, GRATA is using ATF in the system and not the SAE 10/40 weight oil specified by Flxible for the power steering system. They believe the oil degrades under the temperatures and pressures of the power system causing deposits which affect the hydraulic operation. They also indicate that the ATF provides better (faster, smoother) operation in cold weather.

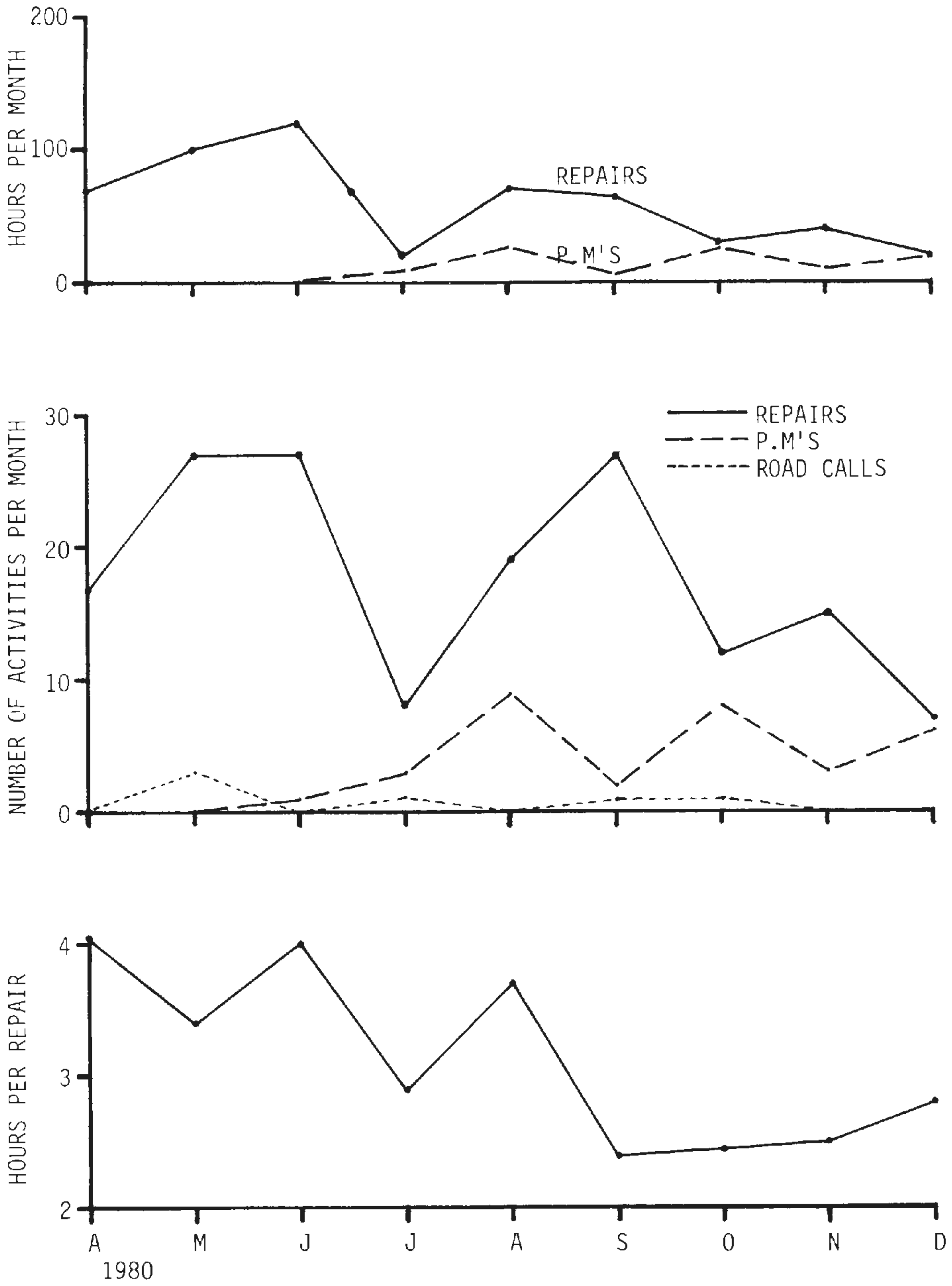


FIGURE 4.7-1: LIFT REPAIR AND MAINTENANCE TRENDS AT GRATA

Table 4.7-1 lists the parts consumption from inventory records at GRATA including parts on order to make repairs prior to any return of the buses to accessible service. This includes the one major item of a hydraulic pump assemply which actually represent two thirds of the parts costs. The average cost per bus was $154 or $17 per bus per month of accessible service.

4.7.3 Lift Maintenance

GRATA initially developed an 18 point three hour inspection and preventive maintenance program based upon 6,000 and 12,000 mile service intervals. This was later consolidated to a single 14 point, 1.5 hour procedure every 6,000 miles as shown in Figure 4.7-2.

4.7.3.1 Mechanic Training and Procedures - No extra maintenance staff were hired for the lift maintenance. GRATA assigned a body mechanic to the lift system and provided the mechanic with training in hydraulic systems, and called upon the services of a designated GRATA electrician for support in the lift electrical system areas.

4.7.4 Summary

Despite low ridership on a limited degree of accessible service, GRATA appears to have been able to maintain a high degree of operational availability of its lifts. A major factor in this appears to have been the establishment and execution by GRATA management of appropriate procedures together with the delegation of responsibility to receptive personnel.

Part Number	Part Description	Unit Price	Amount	Total Cost
97-2631-00294	Hydraulic Pump Assembly*	$1,565.96	1	$1,565.96
97-2631-00290	Directional Control Valve	236.70	1	236.70
97-2794-00157	Step Riser	101.20	1	101.20
97-2631-00223	Loxswitch Actuating Lever	16.66	6	99.96
97-2631-00324	Control Valve Subplate	58.77	1	58.77
97-2631-00277	Riser Cylinder Body	28.86	2	57.72
97-2631-00291	Pressure Relief Valve	43.62	1	43.62
0490-0179-002	Front Slide	42.19	1	42.19
97-3277-00002	Down Limit Switch	41.35	1	41.35
97-2794-00182	Cylinder Head	26.83	1	26.83
97-2279-2	Connector	11.47	1	11.47
97-2279-3	Connector	8.77	1	8.77
97-2279-1	Connector	7.90	1	7.90
97-2631-00156	Cylinder Quad Ring*	2.96	1	2.96
60121002	O-ring Seal	2.87	1	2.87
97-2631-00279	Cylinder Quad Ring	0.25	5	1.25
97-2280-00001	Pin*	0.20	1	0.20

*Parts on order for repairs at time of withdrawal from service.

TABLE 4.7-1: CONSUMPTION OF LIFT PARTS AT GRATA FROM INVENTORY RECORDS

GRAND RAPIDS AREA TRANSIT AUTHORITY

Date________________________________

Coach No.____________________________

Mechanic_____________________________

WHEELCHAIR LIFT INSPECTION

(COACH GROUND LEVEL)

IMPORTANT: Make sure wheelchair lift manual control valves are in the off position before activating the system. Air pressure is to be on front doors in the open position.

_____1. Check oil level at power steering reservoir (refill to just above sight glass) 10W40 oil.

_____2. Activate w/c lift, position lift approximately even with bottom of coach.

Inspect condition of:

_____ A. Multiple drive chain

_____ B. Hydraulic fluid leaks

_____ C. Casing for cracks

_____ D. Check grease zerk at side of gear box, add grease as needed

_____ E. Refill gear box to plug level as required with 90-140 wt. oil

_____3. Check major and minor stop bolt adjustments.

_____4. Inspect electrical wires, connectors and brake interlock micro switch for damage inside w/c cavity well.

(COACH ON HOIST)

_____5. Inspect barrier pump motor oil level. Fill to plug level 10 wt. oil.

_____6. Remove inspection pan from wheelchair lift under carriage. Check chain tension, adjust to maintenance manual specifications. Lubricate idler gear mechanism on single strand chain.

_____7. Inspect electrical wiring and connectors, check for hydraulic leaks, replace inspection pan.

_____8. Inspect underneath lift platform.

_____ A. Electrical wiring

_____ B. Hydraulic line fittings

_____ C. Mechanical friction points

_____9. Inspect all mechanical bearing points on w/c lift system, all hydraulic line fittings. Check outer barrier mechanical and pivot arm. Note: Barrier parts must work freely, lubricate after inspection is finished.

_____10. Inspect lower limit micro switch and electrical connections. Lubricate after inspection is finished.

_____11. Inspect step riser springs and holding brackets. Note: Lubricate after inspection is finished.

_____12. Inspect stabilizer bar rod ends. Grease zerks at rod ends, fill as required.

_____13. Check for proper alignment at nylon step slides and barrier mechanical components going to stow position. Note: Must not make contact with inspection pan.

_____14. Lubricate all mechanical bearing points with motorcycle chain lub. Cycle lift to absorb lubricant into joints, stow lift into park position. Note: Do not force lift against docking edge.

FIGURE 4.7-2: GRATA LIFT INSPECTION PROCEDURE FOR EEC 120B LIFT

4.8 CAMBRIA COUNTY TRANSIT AUTHORITY (CCTA), JOHNSTOWN, PA

CCTA operated seven RTS-2 coaches delivered in January of 1980 with full service starting in February. The CCTA operation was added to supplement the experience of other RTS-2 operators when it became apparent that CCTA was experiencing very high ridership and intensive use of the lifts. The site was visited on July 23, 1981 and discussions were held with Harold Jenkins the General Manager and Michael Quinn the Transit Planner.

4.8.1 Site and System Characteristics

Johnstown has a moderately severe climate with average January minimum and July maximum temperatures of 22.F (-6.C) and 84°F (29°C) respectively together with 35 inches (88.9 cm) of snow and 43 inches (109.2 cm) of rain annually. Johnstown is located on a floodplain and the surrounding terrain is very hilly.

4.8.1.1 Operations - CCTA had 35 buses and required 28 at peak. The seven RTS buses constituted 25% of the peak requirement and were always dispatched if available. Rather than trying to achieve some degree of accessibility on all routes, seven routes were served at a 100% accessible level, without holding any accessible buses in reserve. All seven buses were not always available for service. To ensure predictability for the users, the seven routes were assigned a priority. If all seven buses were not available, the available buses were used on the highest priority routes. There were actually two priority lists in use, the weekday list, and the weekend list. The local community of wheelchair users was advised to call CCTA before starting a trip to be sure that an accessible bus was on the route as scheduled.

Accessible service was implemented without making schedule increases to allow for lift activities, and it was found that drivers could still maintain original schedules. Despite the high ridership (in comparison to other systems), the wheelchair trips amount to only about one trip per day per bus. In practice, schedule delays due to lift use are less than delays due to traffic, and schedule corrections are easy to achieve at the current level of wheelchair ridership. CCTA has documented its stopped time ("driver out of seat time") over several months as follows:

Month (1981)	Riders Per Month	Average Driver Out of Seat Time
January	222	5.38 minutes
February	212	5.34 minutes
March	219	4.79 minutes
April	242	4.40 minutes
May	157	6.50 minutes

4.8.1.2 Ridership and Road Calls - The ridership had built steadily to a level in excess of 200 trips per month. At the same time, road calls remained at a low level and had been zero in 1981 at the time of the site visit. The historical data is shown in Table 4.8-1 and indicates how well the ridership was sustained through the winter months. The data on ridership was believed to accurately reflect at least 85% of the wheelchair ridership, and it was expected that accuracy would decrease, not increase, as lift use became more routine.

Although Johnstown is the site of the Hiram G. Andrews Center, a state-run vocational rehabilitation center, the HGA Center did not by itself generate the majority of wheelchair trips. There is also a sheltered workshop that accounted for a number of trips, and the remainder were individual trips comprised of work, shopping, and other trips. The origin and destination of wheelchair trips was kept for about four months from the start of accessible service in January of 1980, but after that data collection was by route only. There were a number of regular riders who accounted for many of the wheelchair trips with regular to-and-from work commuting. The users from the HGA Center were more transient, staying at the center from three months to over two years. Many of the wheelchair users at the Center had their own cars, and CCTA did not consider that group to be a dominant factor in the high wheelchair ridership attained.

Community acceptance of the service was high. From the start of accessible service in January of 1980, the CCTA had presented a positive attitude toward the handicapped users to make them feel welcome on the system. The major outreach effort was to groups and associations of handicapped individuals, and demonstrations of the bus lift and tie-down system were given to interested groups. A slide presentation was also developed on the use of the lift.

Month	Rides	Road Calls
1980-January	3	0
February	17	1
March	66	3
April	154	1
May	84	3
June	204	1
July	213	2
August	274	0
September	259	0
October	275 (est.)	2
November	328	3
December	223	2
1981-January	222	0
February	212	0
March	219	0
April	242	0
May	157	0

TABLE 4.8-1: CAMBRIA COUNTY RIDERSHIP AND ROAD CALLS BY MONTH

CCTA made every effort to accommodate wheelchair passengers. For example, CCTA has interchanged a lift-equipped bus and a non-lift-equipped bus on one run to accommodate a regular rider, so the person could get to work on time. On the route serving the HGA Center, the bus detours into the Center driveway to bring a wheelchair passenger closer to the entrance, a distance of about 200 feet. The same service is accorded to boarding passengers from the HGA Center if they telephone the CCTA immediately before their trip.

4.8.1.2 Driver Training and Procedures - Drivers received about eight hours instruction on bus operation, including the lift. With the high lift ridership, most drivers became very proficient in using the lift. The most significant shortcoming experienced with drivers was the failure to kneel the bus before operating the lift, to ensure that the ground sensor contacted the ground before another part of the lift. Jacking the bus and bending the lift was a problem early in the program. After a second lift was broken, the driver would have to repeat the lift instruction portion of the training. With the continuing driver education and insistence on kneeling, that particular problem was disappearing.

The drivers were generally enthusiastic about the use of the lifts, and provided an appropriate level of service to each wheelchair patron. With the RTS-2, it is of course necessary for the driver to go to the center door to operate the lift for all wheelchair passengers, but in addition, the CCTA drivers assisted the passenger onto the platform and into the securement clamps, if necessary. (The CCTA buses have only wheel clamps, and no belts.)

In their effort to render service to lift patrons, drivers occasionally allowed more than two wheelchair passengers on the bus, which is now prohibited. Multiple boardings are common, and both securement positions are frequently in use. It was reported that one driver overzealously carried a wheelchair and occupant on board when the lift failed to operate.

Such actions are, of course, prohibited because of the obvious dangers to both the passenger and the driver, and such extraordinary measures are in fact unnecessary. All CCTA buses are radio-equipped, and in the event of too many wheelchair passengers, equipment failure, or any unusual occurrence, drivers are instructed to call the dispatcher for assistance. If the passenger(s) denied boarding is unable to wait for the next bus, the dispatcher will call a taxi or arrange for alternate transportation. CCTA does not pay for taxi rides or the costs of alternate service.

4.8.2 Lift Experience

The mechanical history of the seven lifts was acceptable to CCTA. The major problem was jacking of buses with the lifts when the ground sensors failed to stop downward motion upon ground contact. The usual results of jacking were bent cylinder rods, bent arms, and broken shoulder bolts in the linkage. On two occasions cylinder clevises were broken off. The jackings and other lift problems decreased as driver education and experience increase and also due to CCTA insistence on kneeling the bus before lift operation.

The number of lift parts replaced to July of 1981 was quite low as the total list presented below indicates:

Part No.	Description	Quality	Unit Price	Total Price
2035595	Cylinder	1	171.79	171.79
2035599	Cylinder	4	61.67	246.68
2035929	Panel	2	31.00	62.00
2036864	Switch	1	17.03	17.03
2037237	Arms	16	30.42	486.72
2037243	Bolt (now making own)	25	12.88	322.50
2037245	Bearing	2	2.36	4.72
2037250	Bearing	3	2.83	8.49
2039323	Cover	2	28.48	56.95

The most chronic problem CCTA has experienced with the lifts was the breakage of specific shoulder bolts within the linkage. In terms of actual damage, the bolt breakage was not serious, and in fact, the bolt breakage probably prevented more serious damage in many cases. Replacement bolts were nearly $13.00 each, therefore, CCTA designed a replacement assembly which is mechanically equivalent to a shoulder bolt, consisting of a standard bolt and a spacer collar. The components were available locally for less than a dollar.

Although the required level of repairs of the lift was acceptably low for CCTA, the lift did generate the largest number of repair actions in 1980 and again in 1981 (through June). Table 4.8-2 presents the major repair items and frequency of occurrence. This does not necessarily mean that lifts were the most costly area of repair, since maintenance hours and dollar allocations were not available.

4.8.3 Lift Maintenance

CCTA has 4 mechanics for the fleet of 35 buses, and all mechanics work on any area of the buses, including lifts. The lifts are serviced during the standard 3,000 mile bus checkup. Lift servicing consists of lubricating the lift and operating the lift to check for proper operation and binding or bent parts.

4.8.3.1 Mechanic Training - This is basically on-the-job training, although some of the mechanics did attend the GM school on the RTS-2 bus. The school covered all major systems of the bus, including the lift. In addition to the schooling, a GM service engineer was on-site at CCTA for about four weeks when the buses were delivered.

4.8.4 Summary

CCTA is successfully using the RTS-2 vehicle in accessible fixed route service with sustained year round ridership amounting to one trip per bus per day. A major factor in this has been the positive approach taken by CCTA management and personnel in developing and operating this system in cooperation with the community groups and associations representing the handicapped. The high ridership has undoubtedly contributed to reliable operation by ensuring driver familiarity with the lift equipment and its operation.

	Item	Number	Percentage
1980	Wheelchair lift	29	13.62
	Relined brakes	18	8.42
	Transmission	14	6.57
	Sign rollback	12	5.63
	Radio lightbulb	12	5.63
	Passenger doors	11	5.16
	Waterlines and hoses	10	4.69
	Tires	8	3.76
	Power steering	8	3.76
	Oil	8	3.76
	28 items with less than 8 occurrences each	---	39.00
		213	100.00
1981 (through June)			
	Wheelchair lift	17	15.69
	Rear doors	11	10.20
	Brakes	10	9.26
	Transmission	9	8.33
	Air conditioning	7	6.79
	Tires	7	6.79
	Hubs	5	4.62
	Engine	5	4.62
	Drums	4	3.70
	24 items with less than 4 occurrences each	---	30.00
		108	100.00

TABLE 4.8-2: SUMMARY OF CAMBRIA COUNTY REPAIR ACTIONS FOR THEIR RTS-2 BUSES

4.9 KALAMAZOO METRO TRANSIT SYSTEM (KMTS), MI

KMTS operated eight Chance RT-50's with the Vapor lift, seven of which were delivered in April of 1980, one RT-50 which was originally delivered in 1977 was retrofitted with the lift. The Chance was originally purchased as a heavy duty vehicle for demand responsive work, but did not prove popular with the drivers due to the perceived noise level of the front mounted Diesel engine. The site was visited on June 11 and 12 of 1981 and discussions were held with Terry Cooper the Executive Director, Bob Miller the (new) Maintenance Manager, and other maintenance personnel.

4.9.1 Site and System Characteristics

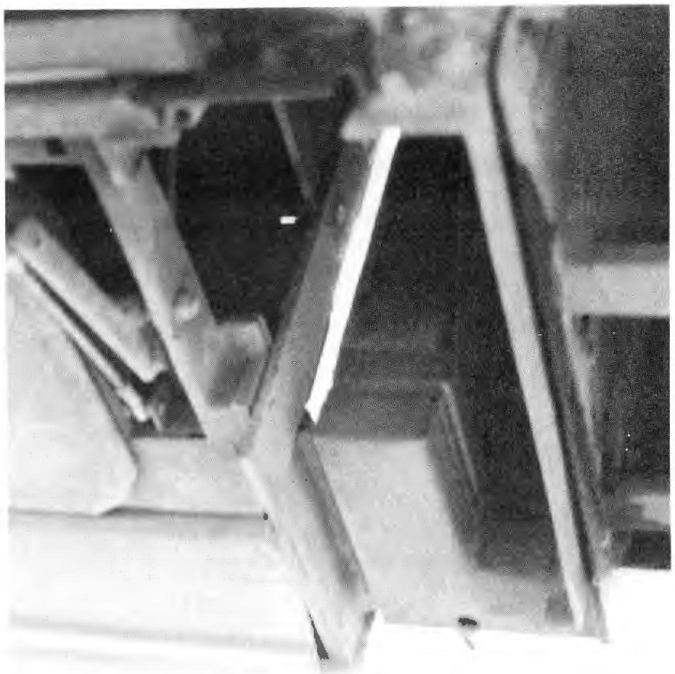
The operating terrain is generally flat, but the overall climatic conditions are severe. Kalamazoo experiences an annual average of 80 inches (203 cm) of snow, ice, and hail plus 28 inches (71.1 cm) of rainfall. January average minimum temperature is 19°F (-7°C) and the July average maximum is 86°F (30°C).

4.9.1.1 Operations - KMTS operates fixed routes with a peak fleet requirement for 40 vehicles plus a demand responsive service. Originally, the Chances were used in demand responsive service, but were withdrawn in the Spring of 1981 in favor of smaller vehicles. They were then used on some of the lower patronage, suburban, fixed route services.

4.9.1.2 Ridership and Road Calls - Historical data was lacking, but ridership was said to be less than two trips per day on the whole system. KMTS has lift equipped RTS-2's as well as paratransit vehicles and road calls were reported as "none to speak of". However, six service calls were found among the available records.

4.9.2 Lift Experience

KMTS experienced a number of problems with the installation including leakage of dirt into the system and into the bus itself (Figure 4.9-1), improper deployment of the endgate, buses delivered with seals missing, and the breaking of pivot pins. They undertook a number of modifications including:



VIEW FROM UNDERSIDE SHOWING GAP INTO INTERIOR OF BUS

CONTROL PANEL WITH COVER AND LOCKED MANUAL CONTROL BOX

FIGURE 4.9-1: ASPECTS OF THE CHANCE RT-50 TRAVELIFT INSTALLATION AT KMTS

1) A plastic flap over the sensitive control push buttons to keep dirt out since removal and repair is a long job (Figure 4.9-1).

2) Addition of a lock to the manual override box. This was done because drivers, who were uncertain of the operating sequence of the panel, had a tendency to use the manual override in normal use (they had been taught how to use it for emergency purposes) due to its simplicity. However, the manual system did not have the functional and the safety interlock features of the normal push-button operated control sequence; therefore, it was potentially dangerous to the equipment and the lift occupant. The RT-50 has the manual control system inside and adjacent to the lift, which encourages its use in the event of difficulty with the electrically controlled system (Figure 4.9-1).

3) Enclosure and waterproofing of some components.

4) Development of their own components in an effort to cure breakage problems.

Complete historical records of repairs were not available, but the available data covering 209 repairs was extracted and analyzed. The activities undertaken were broadly categorized as follows:

Preventive maintenance and general repairs	20.2%
Replace, repair, and adjust switches	19.1%
Straighten and replace linkages and pins	17.0%
Endgate repairs	19.6%
Hydraulic system	8.5%
Repair, replace, and straighten rods	7.4%
Wiring repairs and electrical connections	6.4%
Road service calls	6.4%
Control panel covers, buttons, and bulbs	4.3%

The recorded labor for these activities was 209 hours or 2.7 hours per repair. The parts consumption could not be completely identified, but included at least: 19 switches; 8 pivot pins; 251 bushings or bearings; 15 linkage components; and 6 relays.

There were many parallels between the KMTS and other operator's experience with the vapor lift as evidenced by the high percentage of switch, linkages, and rods and endgate repair activities. Some lifts were damaged during the period when

KMTS drivers had access to the manual control box, however, this was more likely to have impacted the number rather than the type of repair. Many repairs were resolved by straightening rather than having to replace major components, similar to the experiences of other operators. This may reflect the fact that the driver must leave his seat and stand by the lift in the Chance RT-50 operation, thus, the likelihood of severely jacking the bus is reduced. The RT-50 is only half the weight of a full size transit bus which would correspondingly reduce the reverse loading experienced. The positioning of the lift behind the front wheel did seem to aggregate the problem of dirt ingress.

4.9.3 Lift Maintenance

KMTS lift maintenance was based upon a 10,000 mile inspection and lift lubrication. It was noted that while the Chance RT-50 Operators Manual had a Handicapped Vehicle Supplement of 27 pages, only four of these were devoted to lift operation and maintenance.

4.9.4 Summary

KMTS was taking steps to upgrade their maintenance procedures and record keeping, however, it was evident that they regarded the Vapor lift as unsatisfactory and too complex piece of equipment. Equipment problems experienced at KMTS were found to parallel those at other sites with the Vapor lift.

4.10 LOS ANGELES - SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT (SCRTD), CA

Originally, SCRTD was to have been the primary site for the evaluation of the GFC 870/EEC 120B bus-lift combination, but this was aborted by the withdrawal of these buses from service due to the structural problems with the underframes. The site was visited on July 14 to obtain data on SCRTD's deployment plans, evaluation of their previous test programs, and current experiences with the early AMG/TDT bus-lift combination. Discussions were held with Nancy Leon (Operations Analyst), and Mike Leahy (Assistant Director, Equipment Engineering). Russell Petersen of the Equipment Engineering Section provided a tour of #2 Division which operates the AMG/TDT buses.

4.10.1 Site and System Characteristics

The Los Angeles metropolitan area is the second largest in the U.S. and SCRTD has a peak fleet requirement of over 2,000 buses for its fixed route services. The climatic conditions are mild with an average January minimum temperature of only 47°F (8°C) and no snow or ice precipitation. Rainfall only averages 14 inches (35.6 cm) annually and the average July maximum is 83°F (28°C). The dry climate does pose some problems with dust, dirt, and sand accumulations.

As a result of an urgent need to replace its bus fleet, SCRTD has been actively purchasing buses which under California law must be accessible. As a result, in addition to the 200 AMG and 230 GFC 870 buses, it was also taking delivery of 940 of GMC's RTS bus series with rear door lifts.

4.10.1.1 Operations - SCRTD policy is to provide accessible service when all necessary support activities have been accomplished. This includes operator and mechanic training; surveying, lengthening and marking appropriate bus stops, marketing; and schedule printing. In the case of the RTS buses, a proposed deployment plan was constructed with services starting from various divisions at three month intervals so that operation of the whole fleet would be phased in over a nine month period. This phased approach had the advantage of allowing for adjustments to staffing and operations as experience is gained with the equipment. A similar approach will be taken within the GFC 870's when they are returned to service.

SCRTD plans called for the front and rear door lift buses to be deployed on separate routes to avoid confusion. One route was to be an exception to allow comparisons of the relative merits of the two configurations to be made. It is worth noting that in their extensive surveys of bus stops SCRTD concluded that 75% of the stops on front door routes were accessible as is, while the stops on the rear door routes were only 33% accessible.

4.10.1.2 Ridership - Ridership on the original 21 routes operated with the 200 AMG/TDT buses was relatively stable, but at a low level as shown in Figure 4.10-1. The figure also illustrates the effect of the suspension of service while major repairs were made on lift installations. Based upon later telephone conversations, the initial deployment of the RTS buses which increased the number of accessible routes from 21 to 53 also increased the ridership from 15-20 to about 40 per week.

4.10.2 Lift Experience

4.10.2.1 Pre-Service Testing - A primary reason for visiting SCRTD was to collect information the extensive testing to which the AMG buses had been subjected prior to acceptance by the district. This testing was basically an accelerated life test with use of the wheelchair lift. Based upon these discussions, it was SCRTD's opinion that the 50,000 mile road test did not prove to reflect real world conditions in several areas including:

1) Insufficient passenger use in the step mode.
2) No reproduction of the crowning problems due to road and intersection cambers which are quite severe in the Los Angeles area.
3) No way of reproducing the curbing situations.
4) Test drivers are too "nice" to the vehicle to represent the average transit operator.

4.10.2.2 AMG/TDT Series 2 Lift - With respect to the AMG installation, SCRTD's vehicles have a number of modifications developed before delivery and subsequently in-house. The major pre-delivery modifications were a series of locks to prevent horizontal and vertical drifting. AMG's engineering drawings of these modifica-

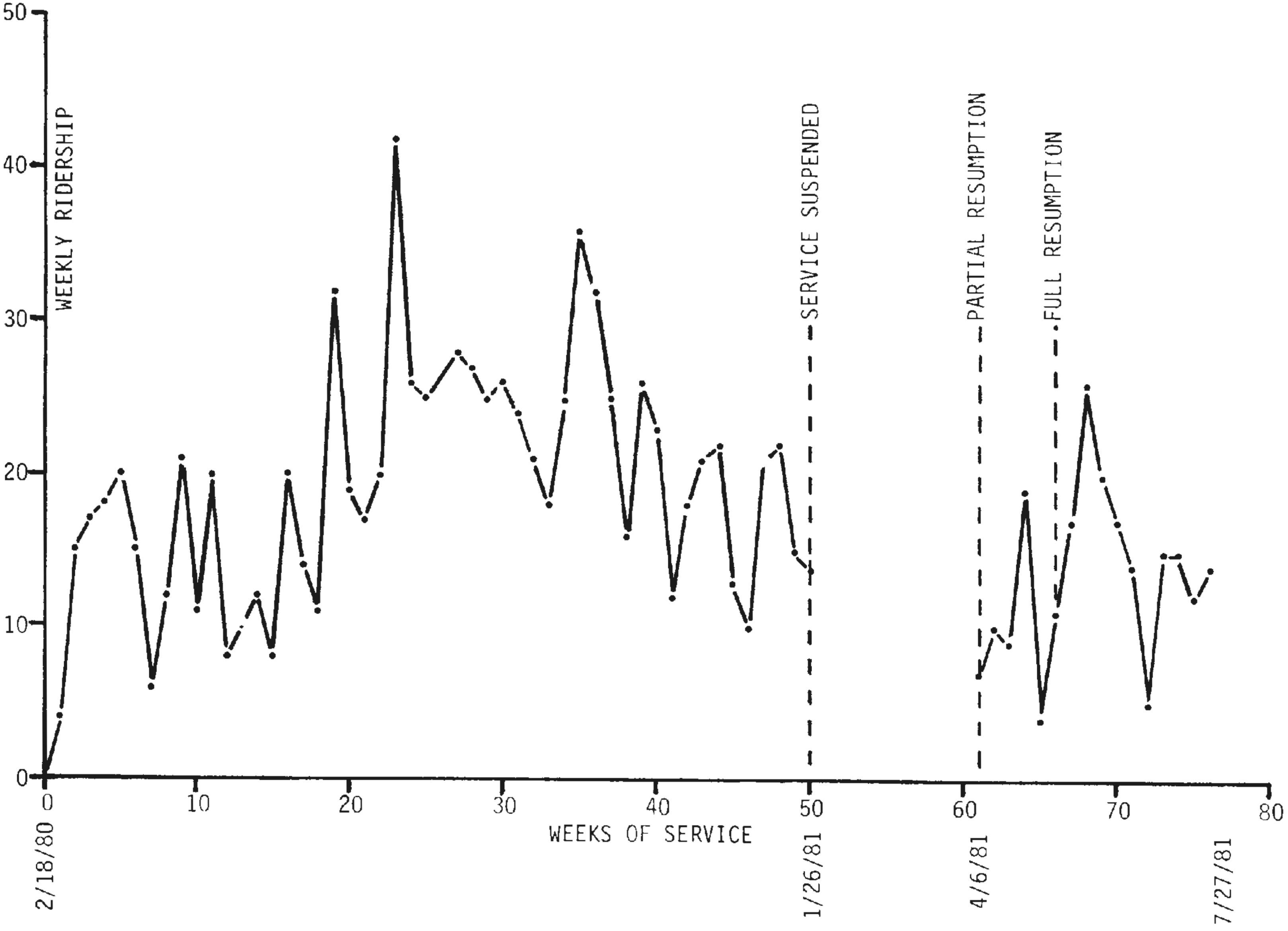


FIGURE 4.10-1: RIDERSHIP HISTORY ON SCRTD'S AMG/TDT BUS ROUTES SHOWING THE EFFECT OF SERVICE INTERRUPTION

tions were inspected. For both of these modifications to work, the control system was modified so that the first (or last) motion is a 3" vertical one. Other modifications included:

1) New sensitive edge with a feather rather than a rounded edge.
2) A flow control valve to each side of the lift to control differential movement.
3) Skid pan at front edge to reduce curbing damage.
4) Cut-off microswitch relocated from behind headlight to the lift structure where it is easily accessible.
5) Lock on the manual control box to prevent the operator using it instead of the normal control system.
6) A cover over the lift switch to avoid accidental activation when turning the steering wheel.

Finally, TDT campaigned the buses to reinforce the welding and added two bolts and a spacer to the lower tower structure to provide an alternative load path. This was in response to a tower cracking problem.

Overall, the test lifts were providing satisfactory performance. The opinions of the mechanics working on the lift were that 85% of the problems were the drivers' fault.

4.10.2.3 GFC 870/EEC 120B Lift - The Flxible 870's with EEC lift were not scheduled to be in service for some time, so SCRTD had made no real assessment of performance. As delivered, the lifts only came to within 1.5" of the ground without using the "relaxing" feature. The lifts were adjusted to reduce the clearance to 0.5".

A higher grade bolt and a reinforcing gusset was being adopted for the handrail and two closure panels were being added under the lift (at SCRTD's request) to seal out dirt.

According to SCRTD there were some welding deficiencies in the lift installations which were to be corrected by GFC at the same time that they made other structural repairs.

4.10.3 Lift Maintenance

SCRTD adopted a policy of hiring extra mechanics for lift maintenance work. The number of mechanics was based upon SCRTD's experience and assessment of the needs of the various lifts. For their three bus/lift configurations, the required numbers were:

Model	Number of Buses	Number of Mechanics	Ratio
AMG/TDT	200	22	9:1
GFC 870/EEC	230	18	13:1
RTS 2/GMC	940	63	15:1
TOTALS	1,370	103	13:1 (approx.)

4.10.4 Summary

The withdrawal of the GFC 870 bus from service did not allow the assessment which was originally intended at SCRTD. It was evident, however, that SCRTD's experience with accessible bus testing and the limitations of these procedures which they had identified could be applied in a general manner to many operations.

4.11 MIDDLETOWN TRANSIT DISTRICT (MTD), CT

MTD was the first operator to take delivery of Bluebird Citybuses equipped with the Collins Steplift. Seven buses were delivered in October of 1980. Discussions were held on November 19, 1981 with Karen Olsen, Transit District Director, Al Robinson, DATTCO Bus Operations Supervisor, and Bill Kenney, DATTCO Maintenance Supervisor.

4.11.1 Site and System Characteristics

Middletown is a small town of about 37,000 population situated on the Connecticut River. The town has numerous hills with steep gradients. The campus of Wesleyan University is in the town center. Middletown has a moderately severe climate with 40 inches (101.6 cm) of snow, ice, hail, and also 40 inches (101.6 cm) of rain. January minimum temperatures average 19°F (-7°C) and the average July maximum is 84°F (29°C).

4.11.1.1 Operations - MTD provides fixed route services on a pulse system from downtown Middletown, normally requiring five buses. The buses are maintained, operated, and garaged by Dattco Bus Company in the neighboring town of New Britain. MTD also provides a demand responsive E/H service.

4.11.1.2 Ridership - There had been no ridership because the buses were not officially introduced into accessible service. The delay was due to lift reliability problems as determined by MTD. It should be noted that the buses were not equipped with radios so that any road call would result in a very considerable service delay before a mechanic or replacement vehicle could be sent from the neighboring town.

4.11.2 Lift Experience

The primary road failure experienced with the Collins Steplift was a failure of the locking system, which allowed the lift to drift in the step mode. The drifting would eventually activate the brake interlocks and immobilize the bus. Table 4.11-1 shows the number of repairs, repair hours and road calls logged by Middletown for the year ending October, 1981. The apparent improvement over the

Month	Repairs		Road Calls	
	Number	Hours	Number	Hours
1980 October	5	69.12	1	2.0
November	5	16.75	3	7.0
December	12	78.70	4	10.0
1981 January	1	1.50	4	8.0
February	9	96.75	2	4.5
March	15	74.50	1	1.0
April	7	39.75	0	0
May	1	1.25	0	0
June	2	2.75	0	0
July	6	3.00	0	0
August	0	0	0	0
September	4	3.25	0	0
October	9	70.25	4	4.5
TOTALS	78	457.57	19	37.0

TABLE 4.11-1: REPAIR AND ROAD CALL DATA FOR MIDDLETOWN, CT

summer months was largely due to the lifts having been immobilized pending installation of new control components. Collins had forwarded a set of heavier duty locks to Middletown, however, the district did not fit them at the time. It was not clear to them whether the locking mechanism was at fault or whether the problem was in the control system which used a microprocessor.

As a check on the Middletown experience, telephone calls were made to the operators with the two largest orders of Collins lifts delivered in 1981. Both confirmed the drifting phenomenon as a major problem in their operations.

The parts consumption for the 12 months at Middletown, Connecticut was difficult to analyze since many of the repairs or campaigns were made in conjunction with the Collins representatives. Based on the records examined, Table 4.11-2 shows the estimated parts use together with Collins' suggested inventory for the district.

4.11.3 Maintenance

The DATTCO personnel appeared to have made a good faith effort to maintain the lifts and the supervisor seemed knowledgeable about the lift system. He stated that Collins had been very supportive and their service representative had been very responsive in visiting the site and assisting with the problems.

4.11.4 Summary

The Collins lift, in its initial operations at Middletown, experienced a major problem with drifting. Drifting problems were also reported by other operators of the Collins lift who were contacted during the study. There was some question in the minds of the operators as to how much of the problem was related to mechanical elements and how much to the microprocessor control system.

Estimated Parts Consumption-Middletown Transit District

Component	#
Switches	7
Solenoid	2
Slack adjuster	1
Cables	2
Pressure sensing switch	1
Edge tubing	1
Mag. switch	1
Power pack	1
Barrier lift cylinder	1
Platform lift cylinder	2
Control box assembly	1
Lift arm step block assembly	6
Plastic Covers	7
Link weld assembly	6

Collins Suggested Inventory-Middletown Transit District

Part #		QTY	Unit Price	Extended Price
SL-156	48" Hose	2	$11.64	$ 23.28
156A	" "	2	11.64	23.28
129	Environmentally sealed switch	4	33.00	132.00
140	Tube	4	0.25	1.00
139	Sponge rubber	2	0.55	1.10
113	Rubber tubing	8	3.23	25.84
2A	1" Lift cylinder	1	64.62	64.62
96	Solenoid	1	60.71	60.71
107	IBT-T252 washer	10	0.86	8.60
106	IBT-TW-51 Thrust bearing	10	0.71	7.10
HA-315	3/8-16X x 1½ CAP Screw	10	0.43	4.30
SL-117	Cam follower	4	10.41	41.64
155	Bearing washer 5/8"	10	2.13	21.30
	Total value of inventory			$414.77

TABLE 4.11-2: LIFT PARTS USED AND COLLINS' SUGGESTED INVENTORY FOR LIFTS

4.12 MILWAUKEE COUNTY TRANSIT SYSTEM (MCTS), WI

MCTS operated 100 Flxible "new look" buses equipped with the Vapor Travelift, with deliveries in March, 1978. The first fifty buses were delivered without the lifts installed and were retrofitted by Vapor at Milwaukee. The retrofit along with other lift problems resulted in a delay in the start-up of accessible service to 1979. The Milwaukee buses were the second major fleet aquisition of accessible buses, Bi-State Development Agency in St. Louis, Missouri being the first. The site was visited on July 6-10, 1981 and discussions were held with Henry Mayer, General Manager, Ralph Malec, Superintendent of Maintenance, and Jim Lynch, Finance.

4.12.1 Site and System Characteristics

The Milwaukee metropolitan area has a population of about one and a quarter million making it the sixteenth largest in the U.S. The winter climate is severe with an average January minimum of 11°F (-12°C) and 45 inches (114.3 cm) of frozen precipitation. Rainfall is 26 inches (66.0 cm) and the average July maximum is 80°F (27°C). Road conditions are typical of older industrial cities.

4.12.1.1 Operations - MCTS provides fixed route services from three garages with a peak fleet requirement of over 500 buses out of a total fleet of 620. The Flxibles were deployed on six routes selected in conjunction with a handicapped advisory group. In August of 1981, the number of routes was expanded to 17 with the additional deployment of 150 lift equipped RTS-2 buses.

The MCTS fixed route accessible service competed directly with a well-established User-Side Subsidy Program (USSP). USSP is an origin to destination demand responsive service that currently averages about 7,000 handicapped users per month, of which approximately half are wheelchair users. The remaining individuals use walkers, crutches, or are legally blind. The USSP vehicles are privately owned taxis and vans. At present, five taxi companies and three van carriers contract to provide service. The user arranges with one of the contracting carriers for his own trip, 48 hours in advance for the van carriers, or in the usual manner for taxi service. Only the vans are lift-equipped or ramp equipped, but about 40% to 50% of the wheelchair trips are made by taxi.

4.12.1.2 Ridership and Road Calls - Table 4.12-1 shows the operational history of the MCTS accessible service through June of 1981. The ridership was markedly seasonal, and appeared to be increasing with both time and the expansion in service. The "other" category represents ridership occurring on routes that were not guaranteed accessible and the data did not allow it to be allocated to a Flxible or RTS route. Prior to August of 1980 it had been included in the Flxible figures. The trouble calls (listed as mechanical failures by MCTS) varied with ridership, but an improving trend was noted. Unfortunately, the MCTS record did not separate the RTS related calls; however, even if all calls were attributed to Flxible buses some small improvement would still be discernible. MCTS data on resolution of trouble calls showed that 80% to 90% of the cases were resolved by the operator (aided by the dispatcher) and road supervisors. Very few road calls or pulled buses resulted from these incidents. In fact, nearly 60% were resolved by the operator indicating unfamiliarity with the equipment and control complexity were probably the major factors governing the reliability of on-the-road operations.

In addition to ridership, MCTS recorded boarding and alighting delay times. An analysis of this data failed to reveal any clear cut trends of front versus rear door configurations despite the fact that the RTS and Flxible buses were carrying approximately equal riderships. It appears that any trends are overwhelmed by the variations due to mechanical problems, weather, etc. Based upon the cumulative results of nearly 1,000 timings the average boarding delay was 5.8 minutes and for alighting, 4.0 minutes.

4.12.1.2 Driver Training and Procedures - Although all drivers were initially trained in the use of the lifts in small groups of four or five, most drivers did not have the chance to board a passenger using the lift. To counter the effects of infrequent use, MCTS prepared a plasticized card for each driver which detailed the operating procedure for the Vapor Lift. It was suspected that some drivers claimed the lift was not working, out of fear or uncertainty of lift operation, when a wheelchair person tried to board a bus. Drivers did not operate the lift on a regular basis, which would have helped to maintain familiarity with the lift. Since the lifts had a relatively high failure rate, MCTS was concerned that driver cycling of lifts could have caused failures in the bus terminals where space and time are at a premium.

Month	Trouble Calls	Boardings Flx.	RTS	Other	Total	Boardings per Call
4/1979	3	29	-	-	29	9.7
5 "	5	34	-	-	34	6.8
6 "	13	47	-	-	47	3.6
7 "	17	59	-	-	59	3.5
8 "	13	61	-	-	61	4.7
9 "	13	56	-	-	56	4.3
10 "	0	6	-	-	6	∞
11 "	3	13	-	-	13	4.3
12 "	6	29	-	-	29	4.8
1/1980	4	19	-	-	19	4.8
2 "	1	9	-	-	9	9.0
3 "	3	7	-	-	7	2.3
4 "	0	2	-	-	2	∞
5 "	2	4	-	-	4	2.0
6 "	3	10	-	-	10	3.3
7 "	11	49	-	-	49	4.4
8 "	10	42	16	13	71	7.1
9 "	7	46	39	6	91	13.0
10 "	8	42	29	2	73	9.1
11 "	4	18	24	0	42	10.5
12 "	7	16	27	0	43	6.1
1/1981	3	8	15	0	23	7.7
2 "	3	8	8	2	18	6.0
3 "	2	10	14	0	24	12.0
4 "	1	26	26	0	52	52.0
5 "	8	66	44	5	115	14.8
6 "	10	67	51	11	129	12.9

TABLE 4.12-1: OPERATIONAL HISTORY OF MCTS ACCESSIBLE SERVICE

4.12.2 Lift Experience

The 100 Flxible buses were equipped with Vapor Travelifts, which represented the first major lift installation for Flxible and Vapor. The first 50 buses were delivered without lifts, however, the bus structure was configured to fit the Vapor lift. For this reason, the subsequent lift installation was not considered a retrofit in the usual sense. None of the lift problems experienced by MCTS were attributed to the late installation of the first 50 lifts.

There were three major problems with the lift:

- Latch mechanism not holding.
- Microswitch failures.
- Bus jacking.

Of these three, the effects of bus jacking remained the most troublesome despite some changes in the ground sensing elements by Vapor. When a lift jacks up the bus, many elements are subject to bending and distortion. Platform parts and linkage elements can usually be straightened and reused. Cylinder piston rods, which have very close requirements for straightness, must usually be replaced if bent. The cylinder itself can also be damaged by bus jacking. Through June of 1981, cylinder and related component parts use included the following items.

Item	Quantity	Cost
Cylinder, Platform	7	$4,074
Cylinder, Elevator	127	$82,550
Piston Rod, Elevator Cylinder	32	$2,819
Hub, Platform Cylinders	66	$2,026
Bolt, Platform Cylinders	74	$1,991
Torque Shaft	13	$1,126

These items with a total cost of nearly $95,000, represented a significant portion of the total lift parts consumption recorded by MCTS of approximately $250,000.

The spare parts consumption data reflected the problems that MCTS experienced with bus jacking, microswitches and corrosion problems. Table 4.12-2 lists the parts consumption costs, based on prices in effect at the time of the assessment, for parts with a total cost in excess of five thousand dollars. These 16 items represent about 80% of the total costs recorded, based on 82 items with a unit price in excess of $10. Through June of 1981, MCTS records show 1,135 switches disbursed at a total cost of over $109,000. This represents the lowest possible limit of switch use, since it was reported by MCTS that Vapor representatives had brought switches "by the brief case full" that went directly to shop floor stock, and were not entered on MCTS records.

The costs were probably influenced by the MCTS practice of using salt on the steps to prevent or clear away ice and snow accumulation. Vapor issued a service bulletin prohibiting such practices, but MCTS was unable to comply in their operational situation. It should be noted that the lift installation precluded the use of the normal hot air ducting installation to the footwell area. Items such as the lower step tread hinge and step assemblies, and riser assemblies were prone to salt corrosion. Costs of these four items through June of 1981 totalled $31,564.

A bus-associated lift problem on the Flxible was found in the distortion of the bulkhead behind the lift on some vehicles. This defect was being remedied as it was found by stiffening the bulkhead. No lift problems were attributed to this condition and it did not appear to be related to bus jacking.

Despite the number of mechanical repairs that had been necessary, MCTS reported only one lift-related accident. When a lift malfunctioned and prevented an on-board passenger from deboarding, the driver attempted to lift the passenger and the electric chair off the bus, and dropped the chair and passenger. The passenger was not injured, but the chair was damaged. The situation of having a wheelchair passenger on board when the lift malfunctions is not uncommon, and in other instances the drivers enlisted the aid of other passengers to help lift the person

Part Number	Component	# Used	Unit Price ($)	Cost ($)
57737042	Cylinder-Elevator	127	650.00	82,550.00
57731704	Switch & Cable Ass'y	162	265.44	43,001.28
57927525	Limit Switch-Step out	374	85.00	31,790.00
57727054-01	Switch-platform	300	84.79	25,437.00
57920407	Bar Ass'y-Pan Activation	309	52.40	16,191.00
57836034	Lower Shield Ass'y	124	101.00	12,524.00
57757286	Lower Step Ass'y	10	966.00	9,660.00
57840361	Cable Ass'y-Platform	16	582.64	9,322.24
57747243	Riser Ass'y	11	816.00	8,975.00
57841163	Latch lock Ass'y	17	509.00	8,653.00
57830714-02	Tread-lower Step	61	128.00	7,808.00
57830689 57537271-01	Link Ass'y-Main	38	170.00	6,460.00
57737223 " " -01	Arm Assembly	113	50.00	5.650.00
57927526	Up Switch-End Gate	76	69.70	5,320.00
57410099-20	Pressure Wave Switch	126	42.20	5,317.20
57737186	Hinge Ass'y-Lower Step	40	128.00	5,120.00

TABLE 4.12-2: COSTS OF MAJOR LIFT PARTS USED AT MCTS THROUGH JUNE 1981

off the bus. A policy was established to call the fire department if a person must be lifted off of a bus. MCTS policy allows only wheelchairs to use the lift, not standees. There was concern about standees losing their balance on the lift and falling, and the possibility that they could strike the top of the doorway.

The MCTS records on the cost of lift repairs, maintenance, and inspection consisted of labor cost and parts cost summaries. The only repair records available were the personal (and sometimes cryptic) records of two mechanics at the main shop. The cost of lift maintenance and repair was accumulated separately since August of 1979. The monthly figures through May of 1981 are presented in Figure 4.12-1. Until March of 1981, the accumulated costs represented only the Vapor/Flxible installation, but at that time the GM RTS-2 buses began to come out of warranty, consequently the MCTS cost figures would begin to reflect some GM lift costs. MCTS reported that there had been no major GM lift repairs in the three months of combined costs, and the figures provided do not show any sudden significant increase. Figure 4.12-1 also shows the cumulative cost per ride. The cumulative figures are presented because the monthly fluctuations in cost and the seasonal nature of the ridership produced large variations. Two trends are shown, for the Flxible ridership only, and for the total system.

4.12.3 Lift Maintenance

MCTS operates from three garages, Fond du Lac, Kinnickimmic, and Fiebrautz, and all garages operate lift-equipped Flxibles. One mechanic is employed full-time at each garage to perform lift maintenance and monthly lift inspections. At the main shop, two mechanics work almost full-time on Vapor lifts. These five positions were created for the lift program. To service the Vapor lifts at the main shops, MCTS added a lateral projection to several in-floor pits that permited a mechanic to work under an extended, lowered lift platform. When the auxiliary pit was not in use, it was covered with planks for the safety of people walking beside the bus, and so that a right front wheel would not be inadvertently driven into it.

The maintenance program at MCTS is based upon nightly and monthly inspections. Nightly lift inspections, performed by the tankers (fuelers), actually occured about twice per week per bus. Buses already inoperative for any reason such as inspections or maintenance work were not cycled. If no malfunction occurs as a

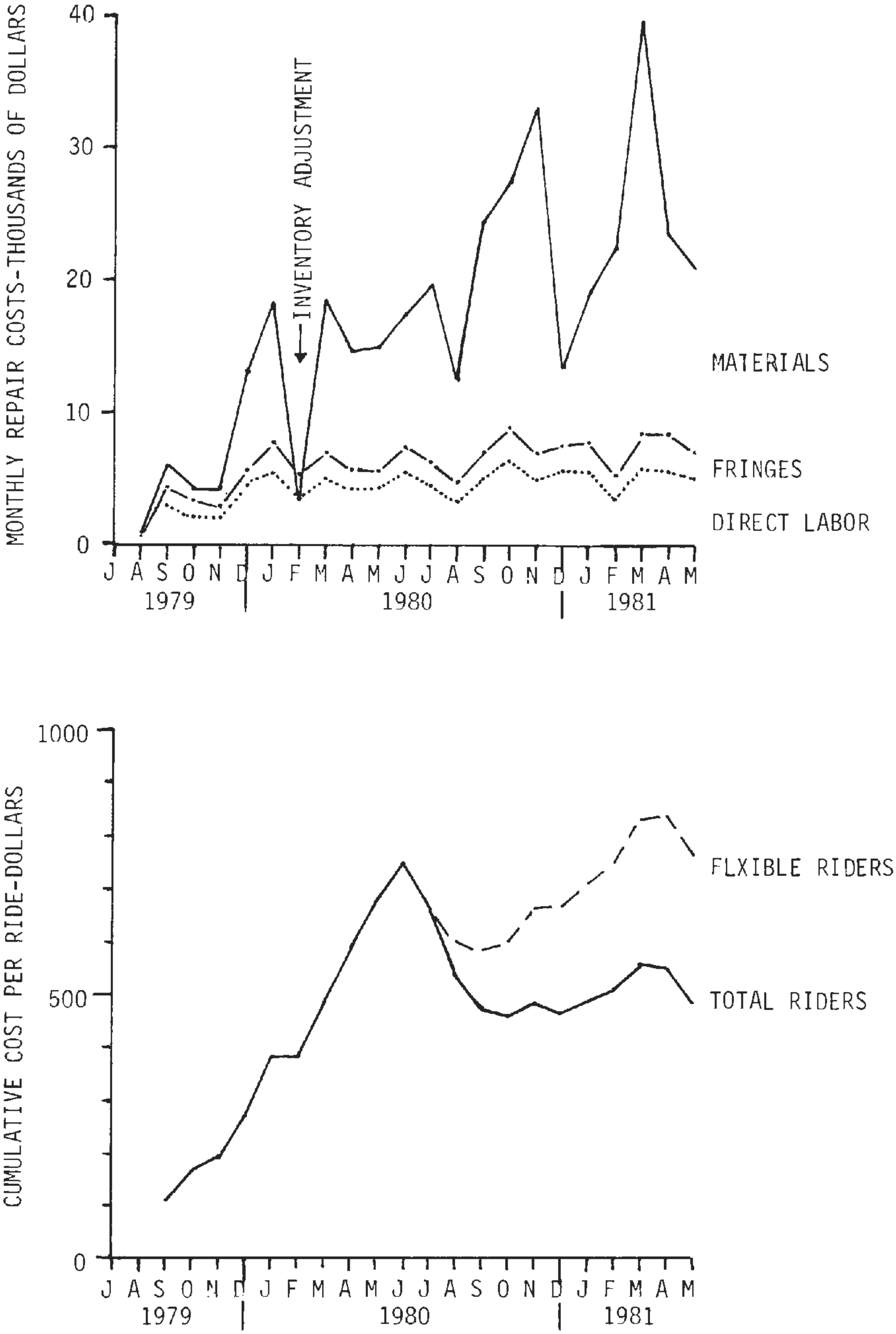


FIGURE 4.12-1: MONTHLY REPAIR AND RIDERSHIP TRENDS AT MCTS

lift was cycled, no inspection report was generated, except for a "Flxible Wheelchair Lift Nightly Cycling" list, which is sent to the main shop. However, the data generated is not tabulated or compiled.

The monthly lift inspection was a two hour preventive maintenance action based upon Vapor's 3,000 and 9,000 mile inspection procedures. The major activity was removal of the end gate and pan assembly which was steam-cleaned to remove accumulated dirt, and then lubricated. When the lift is partially apart, many other items were inspected and lubricated. As the garage mechanics completed a monthly inspection procedure, they recorded only those problems not resolved, such as lack of parts, or a problem requiring the bus to be sent to the main shop for heavy repairs.

4.12.3.1 Mechanic Training - The MCTS trained their mechanics on lift maintenance in a program which they developed based on the repair procedures in the Vapor maintenance manual, plus their own experience. The Vapor maintenance manual is a comprehensive document which the mechanics use as a basic reference for schematics, fluid diagrams, and parts lists.

4.12.4 Summary

The MCTS experience was a costly one which can be attributed in part to being the first operator of the Flxible/Vapor configuration and to their local operating conditions. Despite this, some overall improvement in lift performance was becoming evident at the time of the site visit.

4.13 OAKLAND AC TRANSIT, CA

AC transit took delivery of 175 Flyer buses with Vapor Travelifts from November of 1980 to May of 1981. A brief visit was made on September 2, 1981 to obtain information on initial experiences. Discussions were held with Carol Weinstein, Coordinator of E/H Services, and maintenance personnel at the Emeryville garage.

4.13.1 Site and System Characteristics

AC Transit operates in Alameda and Contra Costa Counties and into San Francisco. The service area includes several localities with severe grades. The climate is dry and warm with 18 inches (45.7 cm) of rain and average January minimums and July maximums of 41°F (5°C) and 73°F (23°C) respectively.

4.13.1.1 Operations - AC Transit operates fixed route service with a peak requirement of over 700 buses. They have experimented with various community oriented demand responsive services. The Flyer buses were deployed on basic trunk routes including those serving BART stations in the East Bay and one Transbay route.

Accessible operations began on June 7, 1981 although the buses had been delivered several months earlier. An extensive pre-service publicity campaign was conducted, including daily demonstrations of the buses at various locations around the system in the month preceding operations, and extensive dissemination of high quality promotional materials. A feature of their promotions was an emphasis on the use of the bus kneeler feature.

4.13.1.2 Ridership - Ridership counts conducted by the drivers (for which they required a premium of $6.00) on two weekdays and one Saturday and Sunday provided the following data:

	Wednesday 7/15/81	Wednesday 8/19/81	Saturday 8/22/81	Sunday 8/23/81
Lift Use-wheelchair	71	44	48	23
Lift Use-ambulatory	23	32	6	12
Total Lift Use	94	76	54	35
Kneeler Use	329	283	137	166

4.13.2 Lift Experience

Operational experience with the lift was limited at the time of the site visit. A high level of support was being provided by two on-site Vapor service personnel. Maintenance personnel estimated that eight lifts were down out of the 155 buses at the Emeryville base. A bus which was used for demonstration had a peculiar interaction in the system that caused the bus to kneel at the conclusion of the lift cycle. The buses were equipped with an extensive kneeling system that allowed either side or both front air bags to collapse. This feature was intended as a means of counteracting the effect of highly crowned roads, to maintain an approximately level platform. There were a number of problems with microswitches, wiring chafed by sliding (protective) side panels, and breakages of outer platform actuating links due to platform jamming upon retraction.

4.13.4 Summary

Initial ridership was high and appeared to be partly due to extensive pre-publicity. Use of the kneeler is a unique feature of AC's operations. The choice of the Vapor lift appeared to have been based on AC Transit's experiences during the Caltrans lift demonstration, program a desire for a large platform of the elevator type for ambulatory use, and a product supported by a major equipment manufacturer. The policy was not being consistently applied since 36 older buses were being retrofitted (in conjunction with BART) with EEC lifts.

4.14 PORT HURON - BLUE WATER AREA TRANSPORTATION COMMISSION (BWATC), MI

BWATC had a fleet of nine Orion buses equipped with the TransiLift which were delivered in May - June of 1980. This was the largest fleet of vehicles in the U.S. equipped with the Transilift.

4.14.1 Site and System Characteristics

Port Huron is a small community of 53,000 on the southwestern shore of Lake Huron. The winter climate is moderately severe with 32 inches (81.3 cm) of frozen precipitation and an average minimum temperature of 19°F (-7°C). Rainfall is 28 inches (71.1 cm) and the average July maximum is 83°F (28°C). Discussions were held with Neil Lambert, General Manager, and Howard Baker, Maintenance Foreman.

4.14.2 Operations

BWATC operates within the SEMTA region, but also receives its own local funding support. All nine TransiLift equipped Orions are used in a pulse system to service eight routes. BWATC also provides area-wide demand responsive services.

4.14.2. Ridership and Road Calls - BWATC had no instance of a single recorded lift patron, although in reviewing the records two service calls for the lift were noted. This appeared to have been due to lift drifting, rather than malfunction during a needed lift operation.

4.14.2.2 Driver Training and Procedures - The drivers were given 2 1/2 hours training on the lift including blindfold operation. There was also a regular monthly meeting of drivers to review all operating procedures.

4.14.3 Lift Experience

Examination of the repair records indicated a number of minor repairs covering such items as chain adjustments, loose electrical and hydraulic connections, and lubrication needs had been made. At the time of the site visit the buses had accumulated approximately 100 months of fleet service. During this period, 43 repairs and adjustments were recorded. The labor time required ranged from 15 minutes to three hours with an average figure of one hour. Total recorded parts consumption was $11.26. Although no ridership was reported two of the repairs to one of the buses were recorded as service calls. This was attributed to drivers experimenting with the lift at layovers.

The maintenance staff felt that most of the problems stemmed from lack of use and that there would be no problem in making the fleet available for use on a regular basis, although it was noted that three of the lifts were not operational on the day of the site visit.

4.14.4 Lift Maintenance

The lifts are cycled three times per week by the night shift, and any repairs and adjustments are completed on a time available basis. No formal training was required after TransiLift personnel provided 12 hours of training during the post delivery period.

4.14.5 Summary

The inherent simplicity of the TransiLift appears to have facilitated their maintenance in an environment where no actual lift ridership was recorded.

4.15 SAN JOSE - SANTA CLARA COUNTY TRANSPORTATION AGENCY (SCCTA), CA

SCCTA was in the process of fitting 219 GFC 870 buses with the new TDT G-50 lift at the time of the site visit 81 similar lifts had been retrofitted into smaller Gillig buses at an earlier date making SCCTA the largest operator of the TDT lift. Due to an ongoing related project which KETRON was conducting for the County it was possible to supplement the information from the site visit with later data from several months of Work Orders on the lift repairs even though full fleet deployment had still not been achieved.

Many SCCTA personnel were contacted for information including: Bob Scott, Director of Transit Operations; Louise Sass, Elderly/Handicapped Coordinator, Transit Operations Division; Jim Lightbody, Transit Operations Division; Arch Walters, Transit Operations Division; John Johntig, Director Fleet Operations; Jerry Oxen, Fleet Operations Division; Larry McFarland, Supervisor, Agnews Training Center; and Ken Larson, Agnews Training Center.

4.15.1 Site and System Characteristics

SCCTA operates throughout Santa Clara County which has a population of over 1 million and which has been one of the most rapidly growing areas of the United States. In parallel with the population increase the transit system has also been growing with new vehicles, facilities and personnel. The operating environment is quite favorable with the exception of some hilly areas in the south and older urban areas in San Jose. The climate is dry and warm with only 13 inches (33.0 cm) annual rainfall and January minimums and July maximums of 40°F (4°C) and 80°F (27°C) respectively.

4.15.2 Operations

The SCCTA operates fixed route services with a peak requirement of 246 buses from a fleet of 460 which includes many old vehicles. It also operates a demand responsive service in the southern areas of the County using a fleet of eleven Mercedes-Benz 309D, small buses.

4.15.2.1 Ridership and Road Calls: The accessible routes used three vehicle types; the 133 Gilligs, fifty RTS-2's and the GFC-870's. The Gillig fleet included 51 with the early model TDT lift and 82 with the later model. Most of the initial operations used the Gilligs with the old TDT lift.

Ridership was determined through driver call-ins; however data from ridership counts, travel diaries and a driver survey indicated that the call-in data was low by a factor of between 2 and 4. Ridership was generally increasing through the period as more routes were made accessible as shown in Table 4.15-1. As more accessible buses were deployed towards the end of the year ridership was being recorded on routes that were not formally designated as accessible. SCCTA endorsed this informal arrangement rather than turn down potential riders or trying to get the drivers to pass them by.

Due to the shifts in bus deployment which occured during this period and the trends noted above, it was not possible to make an exact correlation of road calls and passengers carried for the various bus/lift combinations. For October and November of 1981 the requirement was for approximately 70 buses during which time about 160 trips were recorded on the routes assigned to Flxible buses. During the same period approximately 80 lift related road calls were received. During this same period the Gillig buses using mainly the older TDT lift recorded about 140 road calls while carrying approximately 30 wheelchair trips. It was noted that at the one division which operated Gillig buses with both TDT models, the new lift was experiencing a 50% lower repair rate at a time when the percentage of fleet availability was the same for both lift models.

4.15.2.2 Driver Training and Procedures: A total of 16 hours of driver training on accessible service was provided by SCCTA. This included 2-3 hours of orientation, hands-on training with role playing and handicapped participation at a static display of all of the lift types, and route training during which the driver must cycle the lift at least twice during a run. A yearly refresher program was being provided. Drivers were supposed to cycle the lift at layovers during normal operations to maintain familiarity but it was unlikely that they complied with the policy. A survey of the drivers indicated that only 18% of the respondents rated their lift training as excellent, 35% as good and 38% as fair.

Month	Number of Accessible Routes	Reported Lift Use
1980-May	4	24
June	4	26
July	7	20
August	7	18
September	7	48
October	7	42
November	7	28
December	7	46
1981-January	7	33
February	7	49
March	7	49
April	8	86
May	8	118
June	8	120
July	13	154
August	13	131
September	15	134
October	18	142*
November	18	117**

*Includes 10 rides on other routes.

**Includes 21 rides on other routes.

TABLE 4.15-1: SCCTA RIDERSHIP TRENDS FROM DISPATCHER'S RECORDS
(Refer to text for relationship to actual ridership)

4.15.3 Lift Experience

The SCCTA experience with the GFC 870/ TDT-50 combination was still limited at the conclusion of the project. Completion of the total fleet did not occur until the end of 1981 and only a limited number of the buses had been introduced into accessible service. Further, there were delays in establishing the maintenance program which the County had originally intended to be an extended warranty/service arrangement with TDT. This arrangement could not be agreed upon with the SCCTA union and as a result, maintenance was being done in-house.

The uncertainties imposed by the maintenance situation affected the repair histories. About 70% of the repairs were referred to TDT so that the SCCTA personnel had relatively little exposure to the lift. This was also the situation with the older lifts, and was compounded by the stresses caused by a significant overall service expansion with an old fleet which created unique maintenance requirements.

Table 4.15-2 lists the major categories of repair activities from an analysis of 647 SCCTA work orders for July through November, 1981 which covered the Flxible 870 lift installation. About 65% of the repairs were referred to TDT under the warranty provisions which limited the amount of information available as all TDT records are kept at company headquarters in San Diego. In many cases, however, the actions taken by the TDT field service representatives were recorded although details on costs and labor are missing. Parts consumption and cost data were missing from the SCCTA executed work orders, although provision was made for them to be recorded.

In other similar situations where the operator was not directly responsible for warranty repairs (e.g. RTD Denver) a large number of no problem-found situations arise. In many cases at SCCTA this appeared to have related to safety barriers not working properly which was often attributed by TDT's representative to operation on uneven ground. Adjustments to doors and associated microswitches were part of a campaign to change the lift power circuit sensing to only occur when the door was fully open. As with other systems, the bi-fold doors on the Flxible 870 need to be fully open to ensure reliable lift operation. Anti-drift repairs were generally adjustments to the roller and retaining clips, and sensitive edge repairs were generally a simple replacement of this ground contact strip, which in some

ACTIVITY AREA	%
No problem found or reproduced	29.5
Adjusted doors and microswitch	9.5
Safety barrier system repairs and adjustments	9.1
Adjusted, repaired anti-drift system	6.9
Replaced,repaired sensitive edge system	6.9
Broken,loose,disconnected wires	5.1
Adjusted microswitch (unspecified)	3.8
Added fluid (generally with other activity)	2.9
Replaced,repaired,adjusted lock weld mount	3.4
Replaced stow switch	2.4
Replaced,repaired,slides,rods,shafts	2.1
Electrical problems (unspecified)	2.1
Replace,repair, adjust interlock system	2.1
Replaced pump motor	1.4
Greased and lubed	1.4

TABLE 4.15-2: LIFT REPAIR ACTIVITIES ON GFC 870 BUSES AT SCCTA FROM JULY THROUGH NOVEMBER 1981

cases appeared to have been damaged by bus curbing incidents. Adjustments to unspecified microswitches probably included several more in the door systems. The TDT lift was driven from a electro-hydraulic motor-pump set in this installation and three motor replacements were recorded in each of the last three months analyzed.

One aspect of lift repairs that was accorded particular attention in KETRON's investigation of SCCTA operations was the incidence of damage due to curbing of the front door lifts. The amount of curbing damage is a function of many factors which are not readily analyzed. These include, the number of stops at which the driver must approach the curb at an angle, the height and condition of the curb, the "tightness" of the schedule which will influence the speed of approach, and the vehicles' own suspension and clearance characteristics. Data from non-lift equipped buses cannot be used for comparison because of the influence of the lift installation upon some of these characteristics (e.g. clearances).

The TDT-50 lift by virtue of its design features may be more sensitive than other lifts to the curbing situation because of the 2.5" depth of structure necessary to support the extending tray which forms part of the lift platform. If the top surface of the bottom step is maintained at the same height (pre lift installation), then the lift structure will protrude below the line of the unmodified structure. In the case of the Flxible 870 installation this did not appear to impinge upon the basic vehicle approach angle. TDT machined a chamfered edge to the bottom of the front lift tower to maintain the approach angle on this installation. Nevertheless, with the sensitive edge situated below and at the outer edge of the lift structure line, it is in a more sensitive area.

The approach used to record lift repairs was based on work orders for the GFC-870s and through an analysis of the type of repair made or component replaced. The lifts were still under warranty and many work orders referred the vehicle to TDT for repair. Repairs were discussed with TDT field service personnel wherever clarification was needed. A core of just over 70 repairs (out of over 600) were identified as being related to curbing incidents. These involved repairs to the underside of the lift such as the sensitive edge, safety barrier lock casting, lock weldment, slide rods etc. Only about a dozen of these repairs were done by SCCTA the rest were completed by TDT field service personnel, consequently many repair records were in San Diego. An evaluation of repair data indicated that most were attributable to four causes;

1) Jacking the bus due to failure to sense the presence of ground or curb;

2) Improper operation of the lift by the operator. In particular deploying the lift in the "down" mode, without first ensuring that the platform was fully deployed by selecting the "up" switch position, leading to damage and breakage in the safety barier lock casting area. TDT issued a Service Action Bulletin covering this topic in May, 1981.

3) Component problems relating to the failure of the sensitive edge. This manifests iteself in a variety of lift inoperative, will not go down, and intermittent operation write-ups. Many sensitive edge repairs appeared to fall into these categories.

4) Failure directly or indirectly as a result of curbing.

It was noted that most of the repairs made by TDT were done by one service representative and that on several occasions the sensitive edge was noted as "damaged" or "ripped-off". Obviously those may be attributed to external damage and were probably due to curbing. It could be assumed that other sensitive edges replaced in response to a lift bad order, without any other comment were defective components. Such replacements numbered less than 10 over the 5 month period examined. Discussions with TDT personnel indicate that the lack of detail on the repairs has been a cause of dissatisfaction to them and the service representative concerned is no longer employed by TDT. A corroborating factor indicating that failure of the sensitive edge as a component was not a major contributor to the repairs is the low level or repairs to this component on the Gillig buses once corrective action to reduce curbing incidents had been taken. Figure 4.15-1 shows the potential Flxible curbing repairs under possible and probable headings. In both categories the repairs showed a tendency to decline in the last month of the study and overall were declining in relation to the total bus population.

The experience at SCCTA also indicates that any sensitivity to curbing can be eliminated by placing a local bumper ahead of the lift at the outboard edge. This was done on the Gillig buses (#600-681) that were retrofitted with the TDT-50 lift early in 1981. The bumper, which in this case consists of a solid steel ball, was retrofitted to these buses over the summer of 1981 and dramatically reduced the number of sensitive edge repairs in the subsequent months as follows:

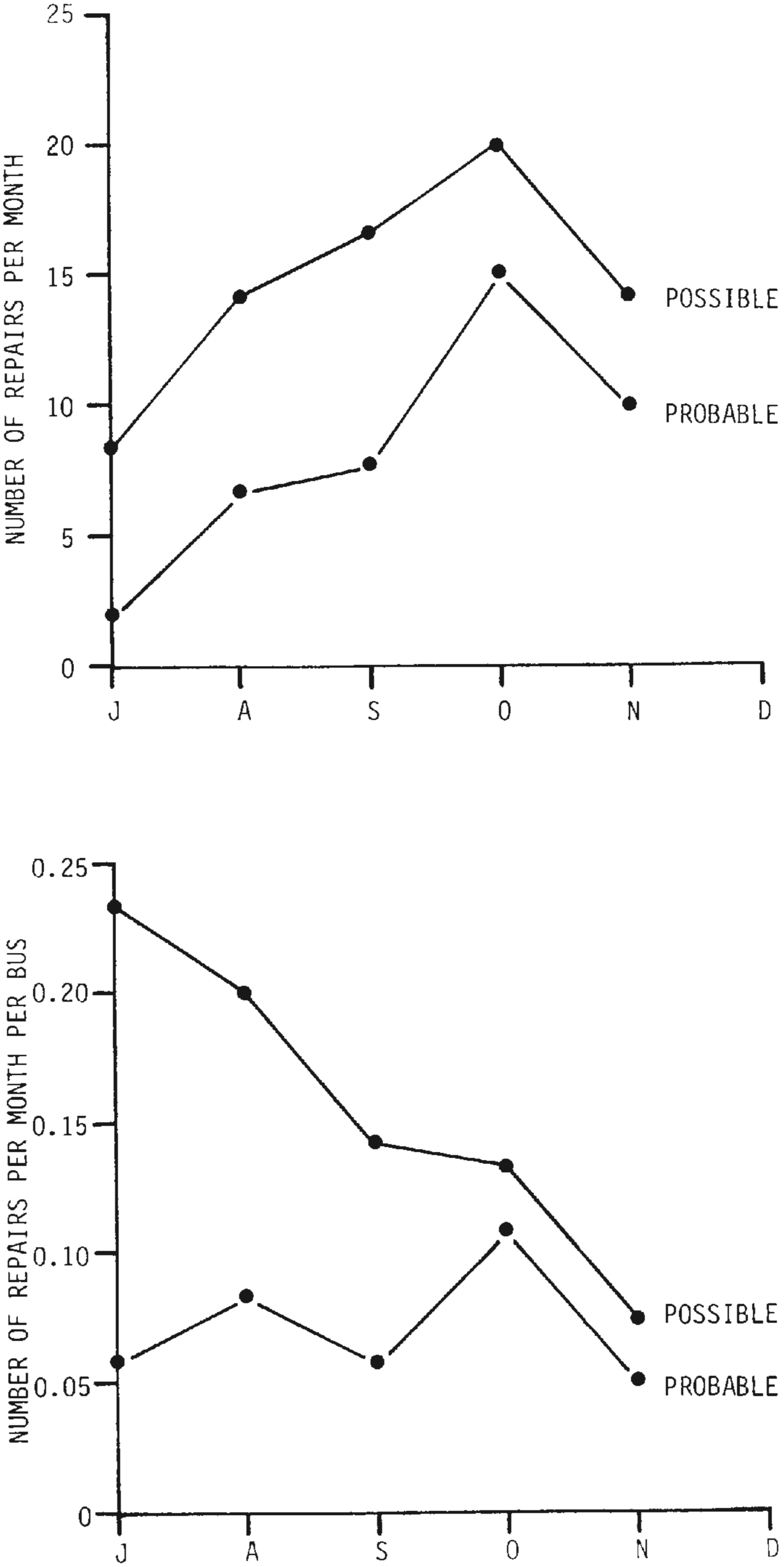


FIGURE 4.15-1: TRENDS OF CURBING REPAIRS ON GFC 870 BUSES FOR JULY THROUGH NOVEMBER 1981 AT SCCTA

Month	Number of Sensitive Edge Repairs North Yard	Central	Total
JULY	17	2	19
AUGUST	10	4	14
SEPTEMBER	1	1	2
OCTOBER	1	1	2
NOVEMBER	1	0	1

The Gillig is smaller, lower, and sways more than the Flxible which increases its susceptibility to curbing damage. Also the majority of these buses were at North Yard and were not run on accessible routes so there was no incentive for the drivers to be particularly careful about the lift installation. With these results, therefore, it appeared that a solution to the lift curbing problem was available.

4.15.4 Lift Maintenance

Lift maintenance procedures had not been established for the GFC-870 installation at the time of the site visit. Surprisingly, this also appeared to be true of the Gillig installation because none of the periodic inspection checklists contained any reference to the lift except for past inspection road tests. In addition, the Gillig factory maintenance manual only referred to the lift requirements with an appendix of reproduced TDT materials at the end of the book. By way of contrast, the procedures for the RTS-2 lift were documented in the appropriate manner and in accordance with GMC's technical materials and formats.

4.15.4.1 Mechanic Training: SCCTA performed its own training in-house with assistance from field personnel from the lift manufacturers. As elsewhere, the industry problem of seniority governing attendance at training sessions has been evident according to observers.

4.15.5 Summary

Insufficient operational experience had been attained with the TDT-50 lift to positively indentify any specific problems other than those noted on other lifts. Overall the initial operations data indicated an expected improvement over the older model TDT lift in the SCCTA environment.

4.16 SAN MATEO COUNTY, CA - SAMTRANS

Samtrans operated 24 AMG buses with the early TDT lift delivered in 1978, 113 Flyers with Mark I Lift-U's and 10 newly delivered Crown-Ikarus articulated buses with Vapor lifts. Although not on the original site list, a brief site visit was conducted on September 2, 1981 to review their operational experience. Discussions were held with Ms. Yamamoto, Operations Supervisor at the North yard in South San Francisco and the maintenance staff. An articulated coach was inspected at Samtrans San Bruno facility.

4.16.1 Site and System Characteristics

San Mateo County has a population of about half a million and is largely subruban/urban in nature with some severe grades at some localities. The climate is moderate with an average January minimum of 40°F (8°C) and only 21 inches (53.3 cms) of rainfall.

4.16.1.1 Operations: Samtrans operates fixed route services throughout the county, into San Francisco and across the San Mateo Bridge into Hayward. Samtrans also provides extensive demand respone E/H services with a fleet of Mercedes 309D and had traditionally emphasized this approach rather than fixed route services.

4.16.1.2 Ridership: No figures on ridership were obtained but it was known to be low.

4.16.2 Lift Experience

Samtrans received the second fleet of Flyers equipped with the Lift-U. The lifts are therefore the earlier model with the platform screw in the under-platform position. The problems that had been encountered according to Samtrans personnel were:

1) a few instances of screws being bent when the lift was run out into a curb;

2) problems with safety barrier deployment due to sticking mechanisms;

3) problems with lift deployment due to dirt and dust accumulations on the screws;

4) some impact damage due to operating on unimproved yard surfaces.

These last three items essentially disappeared after the bus yards were paved and lift lubrication procedures introduced. Inspection of a bus on hoists showed considerable rusting and flaking of the painted steel used and little evidence of the screw having been used. The forward handrail on the platfom had also been bent enough to narrow the entryway appreciably. The middle step tread on this bus had cracked through so it is possible some accident had occurred to bend the handrail.

The Crown-Ikarus articulated buses were brand new and there was little, if any, operational experience with them. The Vapor lift was demonstrated by the base operations manager. In all cases the sensor override had to be used to lower the safety barrier. The controls were neatly mounted on a separate covered pedestal beside the driver which oriented his vision towards the lift. Instructions for operating the lift were on the underside of the pedestal cover. The operating buttons were under a sheet of clear flexible plastic to keep out dirt. The buttons were accessed through matching holes in the steel top surface of the pedestal.

The operation of the lift seemed rather slow partly as a result of the extra floor height of these buses. Samtrans personnel were satisfied with the speed in the context of their schedules and patronage levels. Halfway through the platform down part of the cycle the sliding side plates that shield the mechanism from a lift user fell into place with a pronounced and startling clang. Inspection of the underside of the lift revealed the same exposed mechanisms and leakage paths into the bus interior that had been seen elsewhere. Two mechanical locks on the inboard end of the stowed lift were evident.

4.17 SEATTLE-METRO, WA

METRO had 259 Flyer buses equipped with Mark 1 Lift-U's and was in the process of retrofitting 109 AMG trackless trolleys (buses) with the same lift using their in-house facilities. The site was visited from the 15th through 22nd of September, 1981 and discussions were held with B.J. Carroll, Accessibility Service Implementation Manager; Emmett Heath, Equipment and Facilities Analyst; Bob Gibson, Supervisor of Vehicle Maintenance, North Base; Dave Wyrick, Foreman, North Base; Stuart Bothwell, Systems Supervisor-Transit; Lars Hjermstad, Assistant Consultant Coordinator; Gretchen Roosevelt Marketing; and Marilyn Watkins, Planning.

4.17.1 Site and System Characteristics

The Seattle metropolitan area is the 17th largest in the United States with a population of about one and a quarter million. The community formally adopted a policy of total accessibility in 1978. Downtown Seattle is characterized by severe grades but the overall climate is mild and damp. Rainfall averages 39 inches (99.1 cms) annually and frozen precipitation averages only 15 inches (38.1) reflecting an average January minimum temperature of 33°F (1.C) and an average July maximum of 75°F (24°C).

4.17.1.1 Operations: METRO operated fixed route services with a peak fleet requirement of 726 buses from an active fleet of 1048. METRO had progressively expanded service as buses became available with priority being given to those routes with the highest general ridership. In September 1981 there were 61 accessible routes.

4.17.1.2 Ridership and Road Calls: Ridership increased in step with the service expansion. Ridership was measured periodically and was based on cards that drivers filled out over a number of days covering weekday and weekend situations. The averaged figures for July and August, 1981 (45 accessible routes were being operated) was 131 daily trips or about 4,000 per month. Over 90% of these were wheelchair users. The in-service reliability was good and appeared to be improving slowly as shown by the overall figures below:

Month	Monthly Ridership	Road Calls	Riders/ Call
August '80	896	70	12.8
February '81	2,852	74	38.5
April '81	3,100	88	36.5
July '81	4,410	86	51.3
August '81	3,599	78	46.1

Ridership figures for the system since a service change in September 1981 were not available because METRO wanted to allow several months for the situation to stabilize.

The marked improvement since 1980 reflected greater familiarity with the equipment and the effect of some modification programs. Although the ridership varied greatly on the routes run by the various bases (garages), this did not seem to be a signficant factor in service reliability. A spot check of the July, 1981 figures, as shown below, showed that both the largest and smallest contributors had higher than expected road call levels. It should be noted that North Base is a very old facility.

Base	%of Ridership	%of Road Calls
North	39.8	48.7
Central	30.2	30.8
Jefferson	16.0	11.5
South	13.8	6.4
East	1.3	2.6

4.17.1.3 Drivers Training and Procedures: The drivers received two hours of training in groups of up to four drivers using an accessible bus as a classroom. Each driver operated the lift and took the role of a passenger using a wheelchair. Most drivers appeared to find the training adequate. In addition to training METRO established a Driver Task Force of 8 to 10 volunteer operators representing each operational base. These operators were working on accessible runs or had experience with them and were often old-timers who were well known and respected by the other drivers. Initial meetings were held every two weeks and then monthly; regular meetings were discontinued after a year. At that time a questionnaire indicated that the members felt that they had accomplished all that they could in the way of policy recommendations, problem identification and communications.

The METRO transit operating instructions "the BOOK" features a complete section on accessible service, including procedures for various levels of emergencies. This information was also available in the Operator's Manual for each individual coach model.

4.17.2 Lift Experience

The maintenance records for METRO were extensive and computerized so that the numbers and types of repair could be tabulated. Although the coding system provided 46 categories (Table 4.17-1), in many cases repairs were only recorded under a generalized heading. This appeared to reflect the fact that many of them were minor in nature. Table 4.17-2 presents the reported repair detail of 2036 repairs on the 40' Flyers logged for the 8 months through August, 1981. Only one third of them specifically related to component repairs. For those attributed to trouble calls this ratio dropped to one quarter. As with the road calls, the ratio of riders to repairs improved with expanded service, although not as dramatically. The improvement was only 50-100%, compared to 400% for road calls.

The Seattle buses were the first installations of Lift-U lifts and the individual bus histories were examined to see if there was any evidence of changes in repair frequency with production experience. With one exception within a specific bus fleet, there were no evident trends except those associated with bus assignment to a base. The one exception was in the first buses in the second group of deliveries that are operated out of Central Division appear to have a higher repair rate than the others. No explanation was advanced for this except that it may have been an impact of the change in supplier to Lift-U. The major impact was based on the intensity of use from the routes operated by the different bases. Overall the second group of 40' Flyers appeared to have had a slightly lower per bus repair rate than the first order but this probably reflected the shorter operational history of those vehicles rather than any inherent improvement in

CODE	REPAIR
082-	Chairlift
-003	Body and Chassis
-004	Body electric
-026	Coach interior/signs
-028	No trouble found
-072	Add coolant
-083	Cancelled by coordinator
-084	OK for service
-113	Replace bulb
-122	Repair wiring
-124	Replace/repair switch
-125	Lube and adjust
-134	Adjust linkage
-135	Replace hoses
-141	Adjust microswitch
-142	Lube rollers
-144	Replace handle
-156	Replace/repair cable
-158	Lube
-169	Replace/repair plugs or socket
-175	Clean limit switch
-180	Replace/repair mag valve
-187	Replace/repair line
-228	Straighten pole
-249	Secure wiring
-254	Repair/replace/adjust relay
-260	Replace/repair bracket
-293	Replace clamps
-325	Adjust lift chain
-326	Repair safety gate
-327	Adjust extension system
-328	Repair/replace hydraulic cylinder
-329	Level platform
-330	Clean/lube tracks
-370	Lift malfunction
-400	Tighten bolts
-409	Repair/secure body panel
-411	Repair buzzer or bell
-423	Replace O ring or gasket
-431	Replace/repair valve
-437	Secure stanchion or railing
-444	Clean/lube/adjust
-450	Add fluid
-454	Lube adjust free up
-478	Steam clean
-482	Replace/adjust wheelchair lift
-452	Check accident damage

TABLE 4.17-1: LIFT REPAIR CLASSIFICATIONS BY COMPUTER CODE AT METRO-SEATTLE

REPORTED REPAIR DETAIL	#
No trouble found	47
OK for service	53
Chairlift/Lift malfunction	489
Replace/Adjust lift	38
Lube/lube rollers	288
Lube and adjust	109
Lube/Adjust/Free-up	89
Clean/Lube tracks	46
Steam clean	25
Adjust lift chain	46
Level platform	6
Adjust linkage	7
Tighten bolts	92
Add fluid	4
Secure stanchions/railings	10
Secure wiring	3
Clean limit switch	8
Repair safety gate	16
Repair buzzer or bell	11
Replace/repair mag. valve	7
Replace/repair valve	84
Replace/repair hydraulic cyldr.	7
Replace/repair O-ring/gasket	12
Replace/repair line	80
Replace hoses	4
Repair wiring	170
Replace/repair switch	252
Replace/repair/adjust relay	15
Adjust microswitch/ interlock	5
Replace bulb	5
Body electrical	8
Total	2036

TABLE 4.17-2: LIFT REPAIRS ON 40 FOOT FLYERS BY DETAIL OF REPAIR FOR JANUARY THROUGH AUGUST 1981 AT METRO-SEATTLE

quality. This was confirmed by the fact that in the first four months of 1981 the earlier buses had a 15% higher repair rate but, this difference disapperaed in the following four month period.

The METRO operation was expanding and changing over the period when lift operations were introduced. This included an expanded degree of computerization which involved all base warehouses. A printout of parts consumption was available and complete from April, 1981. The major bases were on line by that date so that for March, 1981 the total parts consumption was fairly accurately recorded. The following table presented the total cost of parts consumed for March through August, 1981.

METRO-SEATTLE PARTS USEAGE

MONTH	NUMBER	COST
March, 1981	45	$2,711
April	18	1,336
May	32	2,123
June	47	3,468
July	18	1,514
August	26	2,395

It is interesting to note that the parts used and costs incurred appeared to have a three month cycle. This appeared to be consistent with inspection periods which generated the more serious repairs. As service expands it was expected that this effect would be reduced.

The costs cover 34 items from a list of 57 parts, however, the majority of the costs are due by a relatively few items. Table 4.17-3 shows the top ten items ranked by cost and also their ranking by numbers used. In the case of part #'s 61100211 through 214 four groups of virtually identical stops were included under one heading. Many of the high cost items related to the platform extension system. The lifts in Seattle were the earliest version of the Lift-U with the mechanism exposed underneath the platform and this may have been a contributing factor to the situation.

NUMBER AND PART		#USED	$	RANK BY # USED
6110201	Drive Nut	33	2840.64	2nd
183	Lift Screw Motor	6	1770.06	7th equal
211-14	Stops	41	1620.32	1st
170	Switch	19	1567.88	3rd
196	Drive Screw	11	1243.44	5th
145	Lift Cylinder	4	748.44	12th equal
105	Dir. Cont. Valve	4	633.28	12th equal
188	Dir. Cont. Valve	5	540.15	10th equal
198	Fr. Cross Beam	2	366.48	16th equal
099	¼" Rod Assembly	8	359.60	6th

TABLE 4.17-3: TEN MOST COSTLY LIFT PARTS USED AT METRO-SEATTLE FROM MARCH THROUGH AUGUST 1981

4.17.3 Lift Maintenance

Lift maintenance was based upon a partial cycling of the lift when the bus came in for servicing each night, and on any bad orders reported by the drivers. Generally the lifts were repaired overnight since most of the repairs consisted of "freeing-up" the Saginaw screw and nut. This was accomplished by a few turns with a wrench on the stub shaft from the hydraulic actuator and took only a few minutes. (This was graphically demonstrated when a bus was being inspected during the visit, and the lift failed to operate.) Apart from routine servicing, scheduled maintenance was performed on a mileage basis related to inspection periods. These may be summarized as:

Every 1000 miles - Check for function - (S inspections)
Every 2000 miles - Lubricate (A,B,C inspection) (Figure 4.17.-1)
Every 12000 miles - Steam out tracks and lubricate (D inspection)
Every 24000 miles - Full lubrication and inspection (F inspection)

The F inspection (Figure 4.17-2) would occur approximately every 6 months with normal bus utilization. METRO does not keep separate records on maintenance labor costs because the low level of effort did not justify it. Based upon discussions with METRO personnel the level of effort at the larger bases appeared to be equivalent to one person full time.

4.17.3.1 Mechanic Training: Because the Lift-U was in effect developed at METRO on a special bus used for dedicated service to a handicapped housing complex, and because of the inherent simplicity of much of the mechanism, no special training procedures were adopted.

4.17.4 Summary

The Lift-U was providing reliable services for METRO under conditions of high ridership and minimum maintenance. A contributing factor was undoubtedly the dedication of the METRO organization to the concept.

LIFT-U WHEEL CHAIR LIFT LUBRICATION

1. The RESERVOIR is serviced with 5W/20 engine oil.

2. ACME threaded shaft and bearings.
   - Clean shaft if necessary and lube with 10:1 spray lube.
   - If bearings at end of shaft appear dry, lube with chassis grease. (Zerk fittings).

3. Main hydraulic cylinder pins, Maintenance manual reference 5-5 (Lift-U). There are two pins, one attaches the cylinder to the power platform structure and is easy to see when the lift is stowed. The other pin is through the clevis on the end of the piston rod attached to the dual sprocket bellcrank. This pin can be seen when the platform is fully "Down"-look between the dual sprockets. These pins are highly stressed and require a special lube.
   - Lube both pins with LOC-TITE ANTI-SEIZE LUBE. Insert the plastic tube and direct spray at pin. Shake can well before using.

4. Chains.
   - Clean if necessary, and spray with 10:1 lube.

5. Safety Gate and Mechanism (flipper arms).
   - Clean the gate hinge with a brush and spray with 10:1.
   - Flipper arm linkage easily reached when the lift is in the "Stowed" position. Spray entire mechanism with 10:1.

6. Angle drive gear box.
   - If leaking, correct leak and refill with 85W/140 gear lube.

7. Tracks.
   - Blow out with compressed air to remove foreign materials.

8. Run lift thru a complete cycle to see that it operates OK.

9. After lift is stowed.
   - Spray ACME threaded shaft once more with 10:1 lube.

10. Hydraulic System.
    - Check for leaks a diverter valve, filter, directional valve bank, hydraulic motor, main and gate cylinders.

NOTE: 10:1 is a polymer type lube - follow directions on the container. Spray on LIGHTLY.

LH/12-80

FIGURE 4.17-1: LUBRICATION PROCEDURES FOR LIFT-U USED AT METRO-SEATTLE

LIFT-U WHEEL CHAIR LIFT "F" INSPECTION ITEMS
-References are attached-

1. Lubricate lift.

2. ACME shaft drive system: See maintenance manual reference 5-7.

    -Check hydraulic motor attach security.
    -Check couplings security to shaft and rubber inserts condition. The inserts should be fit close to metal parts of coupling.
    -Check angle drive gear box attach security. If new attach bolts needed, be sure to install them with the bolt heads down for maximum ground clearance.

3. Main hydraulic cylinder: See maintenance manual reference 5-5.

    -Check that safety clips are in place for both pins. These retain pins at the clevis and anchor ends of the cylinder.

4. Chains: See maintenance manual reference 5-3 and figure 5-6.

    -Check all chain segments for condition.
    -Check that safety retaining clips are installed at each end of each segment.
    -Check that turnbuckle nuts are tight (3 places).

5. Tracks: Each track bolted to bus structure 4 places.

    -Visually check bolt-nuts are secure.
    -Check that track stops are installed, two at outer end and one at inboard end of each track.

6. Power Platform: See maintenance manual reference 5-1, 5-3.

    -Check that the axel nuts are secure for the dual sprocket (1) and for the idler sprockets (2).
    -Check that the carriage roller axel nuts (4) are secure.
    -Check that chain guide thru bolt nuts are secure.
    -Check that lift arm attach nuts are secure (4), at extension arms.
    -Check that limit switch strikers are secure (2). One for the outboard and one for the inboard limit switch.

7. Lift Platform: See maintenance manual reference 5-1, 5-2, 5-3.

    -Check lift arm attach nuts (4) security.
    -Check safety gate hydraulic cylinder attach security, gate linkage condition.
    -Check safety gate hinge condition.
    -Check "flipper" arms, cams and mechanism for condition and security.
    -Check platform condition, anti-skid tread, grab rails security and paint.
    -Check platform safety markings condition.
    -Check wedges (2) for security.

8. Operate lift and check that it is operating properly.

FIGURE 4.17-2: "F" INSPECTION (24000miles) FOR LIFT-U USED AT METRO-SEATTLE

SECTION 5
CONCLUSIONS

The assessment of passive lifts on fixed route transit buses disclosed a wide variation in performance of the various designs and installations at the various transit properties visited. The assessment process resulted in some overall conclusions, as discussed in this section, with respect to lift design and specification, testing and check-out procedures, and operational procedures for mechanics and driver.

5.1 LIFT DESIGN AND SPECIFICATION

Apart from isolated instances, the overall performance of all lifts has been satisfactory. The major areas of concern center upon a few specific design and specification items.

5.1.1 Ground Sensing

The bus jacking problem accounted for almost all of the physical damage to lifts encountered at the sites. Failure of the safety barrier to lower was also a common occurrence. Both of these problems are due to failures of sensor systems to detect the ground. Apart from malfunctions within the sensor systems, the ground detection limitations were mainly attributable to operating in a real world environment of crowned roads, uneven curbs, and rough bus stop surfaces.

5.1.2 Microswitches

Most of the lift designs that use microswitches have had problems with failures, component quality, and the need for continual adjustments. Environmental protection of those items has been a particular headache.

5.1.3 Component Design, Replacement, and Repair

Many instances were noted where failures of relatively expensive components were greatly influencing the overall service costs. These ranged from failures of a few very expensive items (>$1,000), such as valves and printed circuit assemblies, to multiple failures of lower cost items (<$100), such as specialty nuts and bolts. It was concluded that more design emphasis should be placed on the use of standard, readily available components, and to provide for in-house repair of costly components, rather than repair by replacement. It should be noted that in some instances where the lifts were still under warranty there was little incentive for the operator to adopt such a philosophy. It can be expected that there will be more interest in such design features as the lifts become older.

5.1.4 Accommodation of Powered Chairs

The use of accessible transit by persons in powered chairs appears to be far higher than the historical distribution based upon wheelchair sales would indicate. Limited data from a 1978 report* indicated that less than 5% of wheelchair sales (based on one major manufacturer) were powered chairs. Observations and discussions at the sites visited indicated that in many instances the proportion of powered wheelchair riders was more than 10%. There is some evidence that this trend is increasing as the overall environment becomes more accessible. Powered chairs are also being bought for the mobility they provide as well as for the needs of specific disabilities. It was concluded that lift designs and installations must consider the powered chair, including dimensions, weight, and maneuverability limitations. Particularly important are safety implications arising from increased speed and weight, such as impacts with the platform safety barriers and the possibility of running off the platform sides if the powered chair is not properly controlled.

5.1.5 Controls

Numerous comments and opinions were received on this subject and many properties had developed their own decals and reference cards for guiding their drivers through the correct process for operating the lift. There were conflicting opinions since some operators of lifts with numerous control buttons or switches felt that it was not too complex. While other properties using considerably simpler lift controls believed it was necessary to supplement the manufacturers'

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*Sanders, Marks, "A Requirements Analysis Document for Transit Vehicle Wheelchair Lift Devices", Canyon Research Group, UMTA Contract DOT-UT-60106 T, 1978.

instructions by numbering the controls in sequence. A primary concern was to avoid stowing of the platform with a wheelchair in place. Mechanical devices such as load or presence sensors have been proposed but they represent yet another system that is a potential trouble spot in an already complex system. Overall, it was concluded that a simplified, well separated, and well positioned manual control should be adequate based upon the safety record to date.

5.2 LIFT INSTALLATIONS

The trend towards a modular lift construction which provides a neater, easier installation was evident in all designs. Some of the problems noted with such installations are presented in the following.

5.2.1 Door-Lift Clearance

Many instances were reported of lift platforms or handrails striking or becoming jammed in the door. It was concluded that this was primarily a result of tight clearances resulting from installation of the maximum size lift into existing doorways. The clearance problem was compounded in vehicles with bi-fold or parallel motion doors where the panels could rebound or where the fully open position was not well defined. Another contributing factor was the use of lift power-on switches that were triggered by the door starting to open. This enabled an anxious driver to begin deploying the lift before the door was fully open.

5.2.2 Sealing

There appears to be a general need to improve the overall sealing of the lift installation to keep out dust, dirt, and noise and to maintain the interior environment. This is a problem which will increase with age as door seals wear and as the springs on closure panels weaken.

5.2.3 Stepwell Heating

An almost universal problem in cold weather climates (which is aggravated by the current trend to modular construction) is the inability to provide heat in the stepwell with ducting systems to prevent ice and snow accumulation. The problem can be addressed by either the lift or the bus manufacturer; however, it was concluded that it would be best if the bus manufacturer had overall responsibility for providing this feature where required.

5.2.4 Remote Control

When the lift is deployed, access to the driver's area is difficult, and almost impossible if the bus is on a hoist. From observation it was concluded that in many cases the productivity of maintenance personnel could be enhanced by providing for operation of the lift from the outside through some form of remote control.

5.2.5 Control Panel Layout/Location

In addition to the many different control modes required for the different lifts, each bus may have a different position for the control panel depending upon the available space in the dash area. It was concluded that, in most cases, little thought seems to have been given to human factors design in control panel installations. Most controls were not in the drivers line-of-sight to the doorway and the view could be blocked by a large farebox. In some cases, two-handed operation is required which further restricts the driver from adjusting his position for a better view.

5.3 TEST AND TESTING

It was concluded that existing testing practices (Figures 5.3.-1 and 5.3-2) are deficient in many respects, although they appear adequate to ensure the basic mechanical integrity, and possibly the longevity of the lift. Present lift tests do not simulate the actual conditions of bus installation and operations, and bus endurance testing has not reflected some important road conditions and ridership considerations. Similarly, it was concluded that acceptance testing, while effective in ensuring functional lifts upon vehicle delivery, has not been useful in uncovering longer term problems with an installation.

SEQUENCE OF TEST	NUMBER OF CYCLES	LOAD (LB)	TEST CONDITIONS
1	600	595	Ambient temperature in first half of each of these tests will be at least 110°F. Tests may be continuous or intermittent with ≤ 1 minute between groups of ≥ 10 cycles. Vertical and Horizontal accelerations shall not exceed (0.3 g) during first and last 5 cylces.
2	15,000	375	
3	10,000	0	Temperature and rest period as above.
4	10	0	Ambient temperature ≤ 20°F. Pre soak for 5 hours. Rest for > 30 minutes between each cycle.
5	2	0	With limit switches inoperative. Power maintained for 5 seconds at deploy stow, fill up at floor and full down at ground level position. Lift stationary in raised position. Load uniformly distributed around center of platform within an area not exceeding a 60 X 60 (24 X x24") square.

ALLOWABLE MAINTENANCE: During the durability tests, the inspection, lubrication, maintenance, and replacement of parts (other than bulbs and fuses) may be performed only as specified in the owner's manual for the lift and at intervals no more frequent than specified in the manual. Maintenance specified for certain time intervals shall be performed during the vertical cycling and deployment cycling tests at a number of cycles that is in the same proportion to the total cycles as the maintenance period is to 36 months.

VISUAL INSPECTION: At the conclusion of the tests described and with all loads removed, the parts of the wheelchair lift shall show no condition of fracture, permanent deformation, extreme wear, perceptible impairment, or other deterioration that would be hazardous to the occupant or operator.

NUMBER OF UNITS: Only one representative production unit of each model is required to be tested for certification with all tests conducted on the same unit

FIGURE 5.3-1: CALIFORNIA HIGHWAY PATROL DURABILITY AND SELF-DAMAGE TEST PROCEDURES

MILEAGE

- o 50,000 simulated odometer miles (500 laps of 14.2 miles with overall severity rating of 7.043)

CYCLES

- o 6,240 lift cycles - 50% with coach knelt
  50% with coach normal height

  NOTE: One cycle is defined as embarking and disembarking the wheelchair.

LOADING

- o Electric chair and occupant of 350 lb. total weight.
- o Two walking passengers to enter and exit the bus before or after the lift cycle.
- o Overall vehicle loading to 150% of seated capacity.

PROCEDURE

- o 240 laps during each of which the lift will be cycled 13 times (alternately 7 knelt, 6 curb then 6 knelt and 7 curb)
- o 260 laps during each of which the lift will be cycled 12 times
- o Two shifts will be conducted, five days a week
- o Eight laps will constitute one shift

ENVIRONMENTAL FACTORS

- o Testing to continue in inclement weather unless course is rendered unsafe due to deep snow or icy conditions.
- o Once per shift (i.e. 62 times during the whole test) bus will be driven through a salt water trough at 5 mph.

INSPECTION, MAINTENANCE AND REPAIR

- o A critical examination of the coach and lift mechanism to ascertain course severity.
- o No adjustments except manufacturers recommended normal preventive maintenance.
- o Repair or replacement of any failed mechanical, hydraulic or electrical device may be cause for restart of test.

FIGURE 5.3-2: EXISTING ACCESSIBLE BUS TESTING SCHEDULE

5.3.1 Lift Tests

Some specific areas where it was concluded that existing lift tests are deficient include:

- Lack of low temperature testing.
- Lack of humidity and precipitation testing.
- Use by lift manufacturers of low viscosity hydraulic fluids whereas bus systems often use 10/40 or 20/40WT oils.
- Insufficient cycles and duration to the self-damage test.

5.3.2 Bus Tests

Some specific areas where it was concluded that existing bus/lift testing has been deficient include:

- Too many wheelchair cycles, both in absolute terms and relative to the number of ambulatory passenger. The most intensive usage to date suggests no more than one wheelchair passenger per bus per day. At this level of usage an appropriate ratio of wheelchair to ambulatory passengers is likely to be in the range of 1:150 to 1:300.
- Lack of crowned intersections which are traversed at typical bus speeds.
- Lack of curb approaches.

5.3.3 Acceptance Tests

Acceptance testing in general has been concerned with the mechanical functioning of the lift on each vehicle. While this is sufficient to meet contract requirements, it was concluded that there was some merit to the idea of taking at least one of the first vehicles delivered, and performing more extensive cycling to get an early indication of any potential problem areas.

5.4 TRAINING AND OPERATIONAL PROCEDURES

A great diversity of practices and procedures for the training of operators and mechanics was evident from the site visits. This reflected the varying committment, fleet size, and facilities of the operator; the complexity of the lift control; and the anticipated/actual ridership. The greatest diversity was in the procedure for regular cycling of the lift. This is invariably recommended by the lift manufacturer (at a minimum of once a day) to ensure reliable operation. The transit operator has another objective and that is to ensure that the bus driver maintains familiarity to ensure safe and trouble free operation of the lift. These two cycling requirements are not necessarily identical. For the purposes of maintaining operator familiarity, the lift should be exercised through the full cycle; however, to maintain the mechanical condition of the lift only a partial cycle may be necessary, depending on the lift design and expected problem areas. The different cycling procedures encountered at the sites included:

- Daily cycling by operators with a paid allowance of up to 15 minutes for checkout.
- Daily cycling by servicing staff on bus pull-in.
- Daily cycling by graveyard shift maintenance staff.
- Two or three times a week cycling by operators, servicing, or maintenance staff.
- Bi-weekly cycling during brake inspections.
- Random chance or viturally no cycling.

Some of the reasons for minimal lift cycling included operator concerns about the inability to supervise or enforce this activity, fear of reduced bus availability and creating traffic jams in the bus yard; along with a lack of operator motivation due to low utilization of the lifts by passengers. At least one property with a simple lift, relatively high ridership, and good committment was successfully operating without regular cycling.

All properties had driver training and orientation programs varying from two to eight hours in length. The need for refresher training was being increasingly recognized, particularly in those situations where drivers did not operate the lifts on a frequent basis.

With respect to mechanic training, it was concluded that two major problems had been identified: (1) ensuring that the right mechanics received training; and (2) ensuring that appropriate training was available.

The first problem arose from the trend within the transit industry to avoid specialized labor categories and union seniority considerations for determining which personnel attended training courses. At several properties the statement was made that those attending training courses did not subsequently bid for lift work in the shops. It was also observed that younger mechanics were more attracted to the challenges of lift maintenance.

Training availability is subject to geographical and resource limitations. In the absence of a centralized training establishment such as the General Motors Technical Center at Warren, Michigan, most training has been provided on-site by technical service representatives. Unless they were an established vendor such as Vapor, or directly associated with a major bus manufacturer such as Flxible, the smaller individual lift manufacturers were dependent upon their own limited resources. Lack of service support is still a major issue in the industry although the situation has improved greatly over the last two years.

A centralized training school also has its limitations. Few of the smaller properties felt they had the resources or justification to send mechanics on a three day trip for a one day course. Some of the larger properties such as RTD Denver devoted considerable effort to in-house training facilities.

SECTION 6
RECOMMENDATIONS

This section presents some significant results of the project in the form of guidelines and recommendations for the general areas of lift design and specifications, testing and acceptance procedures, procurement requirements, safety considerations, and training and operational procedures. These areas are all interactive and a clear-cut separation of the topics cannot always be made. This is particularly true when the lift is considered as a piece of hardware that is only one part of a total system installed in a vehicle. The satisfactory in-service performance of the total lift system is of primary importance to the transit property.

6.1 LIFT DESIGN AND SPECIFICATIONS

The recommendations here may be conveniently separated into items concerning the lift design or the lift installation.

6.1.1 Lift Design

Generally, the design performance of the lifts studied in this project has been satifactory. It is recommended that the following areas be addressed in order to improve lift design and overall performance.

6.1.1.1 Accommodation of Powered Chairs - It is recommended that lifts accommodate the most common powered wheelchairs such as the Everest and Jennings 3-P, Invacare Rolls IV and Orthopedia. These chairs typically have 48" overall length with leg rest extensions, use 20" diameter driving wheels and may have anti-tip extensions to their underframes. The platform, with safety barriers raised, should accommodate these chairs with the passenger facing in either direction.

6.1.1.2 Avoidance of Bus Jacking - In practice, ground contact can occur at any location under the lift. It is recommended that lifts should be designed to accommodate this situation through improved sensor design.

6.1.1.3 Sensor Failure Damage Prevention - In the event of ground contact sensor failure the lift should be designed to limit jacking loads or fail in such a way that major damage will not occur.

6.1.1.4 Switches - It is recommended that as lift designs are refined, an effort be made to eliminate switches whenever possible, as opposed to replacing one type of switch with another. Switches that cannot be eliminated should be located as high as possible in the lift module. At a minimum, switches should be eliminated from the underside of platforms.

6.1.1.5 Component Design - In addition to component quality, lift design needs to reflect component replacement and cost beyond the warranty period. This includes avoiding the use of special parts, allowing individual components to be changed, the use of seal kits, and provision of diagnostic equipment to troubleshoot integrated electronic circuits.

6.1.1.6 Control Simplicity - Control sequences should be simple, distinct, and separated wherever necessary for safety of operation.

6.1.1.7 Safety Barrier Integrity - It is recommended that present design standards, together with current production model configurations, be reviewed to ensure that a powered wheelchair under full forward and reverse accelerations cannot override the lift safety barrier.

6.1.2 Lift Installations

Recommendations have been established in a number of areas for improvement of the bus installation.

6.1.2.1 Open Door-Lift Clearance - Ensure that a positive design clearance has been incorporated to allow for normal manufacturing tolerances and to allow for partial opening or for rebound of the door panels.

6.1.2.2 Door Open-Lift Activation - Lift power circuit activation should not occur until the doors are fully open.

6.1.2.3 Lift Platform Elevation Angle - The installed platform loaded with a powered wheelchair should have a zero or slightly positive angle of elevation.

6.1.2.4 Lift Underside Clearances - The underside clearances and approach angle of the bus should not be changed by the lift installation.

6.1.2.5 Lift Installation Sealing - Adequate sealing is necessary to preserve the buses' heated or cooled internal environment, and to keep dirt-sensitive components clean.

6.1.2.6 Stepwell Heating - Bus manufacturers should offer some form of stepwell heating with each type of lift installation, as a customer option.

6.1.2.7 Remote Control - Operation of the lift from outside or underneath the bus (for maintenance purposes only) should be possible.

6.1.2.8 Control Panel Location - More consideration should be given to the placement of the lift control panel within the drivers line of sight toward the entryway.

6.2 TESTING AND ACCEPTANCE

The following recommendations are essentially modifications or additions to existing procedures which conform more closely to actual operating conditions.

6.2.1 Lift Tests

6.2.1.1 Low Temperature Tests - It is recommended that the temperature range should be extended to be more representative of "snow-belt" communities with -20°F (-30°C) as the recommended low temperature test point.

6.2.1.2 Specification of Hydraulic Fluid Used - Lift manufacturers should have to specify the working fluid and its viscosity characteristics used in their testing. Any deviation from this by the bus manufacturer should be a cause for retest and verification to the customer.

6.2.1.3 Self-Damage Test - It is recommended that this test should be revised to reflect either a greater number of cycles (≥ 10), longer times (≥ 15 seconds) or failure or load limiting capability without damage to major working components.

6.2.1.4 Environmental Test - It is recommended that in addition to the temperatures of 6.2.1.1, humidity and precipitation conditions should be simulated on an installed lift.

6.2.2 Vehicle Endurance Tests

Vehicle endurance tests should reflect a much lower absolute level of lift usage and a much higher ratio of ambulatory use. Suggested values are:

6.2.2.1 Lift Usage - 350 complete cycles per 50,000 simulated vehicle miles.

6.2.2.2 Ambulatory Usage - 350,000 entering passengers and 180,000 exiting passengers per 50,000 simulated vehicle miles.

The endurance tests should also better reflect route conditions including:

6.2.2.3 Crowned Intersections - The bus should traverse a crowned intersection at 20 m.p.h. once each lap.

6.2.2.4 Curb Approaches - The bus should make a 45 degree approach to an 8" curb at 5 m.p.h. every 8 laps.

6.2.3 Vehicle Acceptance Tests

Vehicle pre-delivery acceptance tests typically consist of a number of working loaded and unloaded cycles. Unless the bus manufacturer is conducting 100% quality assurance checks on purchased lifts, the pre-delivery check should include:

6.2.3.1 Proof Load Demonstration - Stationary lift in raised position loaded with 410 kg. (910 lb.) as per California Highway Patrol requirement.

The vehicle (or vehicle model) should also demonstrate the area and sensitivity of platform ground contact sensing.

6.2.3.2 Sensitive Area of Platform - The underside of the platform should as a minimum be sensitive to ground contact across the width of the platform and from the inboard end of the safety barrier to a line parallel to the outside of the front tire on full left lock.

6.2.3.3 Sensitive Height of Platform - The platform shall sense a 1"x1" square protrusion above a level surface placed anywhere under the platform sensitive area. The height of the protrusion shall be such that the ramp angle of the deployed safety barrier shall not exceed nine degrees.

6.3 OPERATIONAL PROCEDURES

6.3.1 Daily Cycling of Lifts

It is recommended that daily cycling of the lift by the bus operator be required to ensure maximum reliability of service at the bus stop. This procedure is not necessary when ridership levels indicate that drivers will maintain their familiarity with the lift through on-the-road operation.

6.3.2 Driver Refresher Training

It is assumed that all drivers receive training and will at some time receive refresher training. It is recommended, however, that all drivers on accessible routes should be given refresher training following a route pick or prior to a service expansion.

6.4 PROCUREMENT REQUIREMENTS

Procurements may be for new accessible buses or for a retrofit into existing buses. Depending upon the actual situation, it is recommended that the procurement documents include some or all of the following.

6.4.1 Description of Operation

A brief statement of the fleet size, number of divisions, maintenance facilities, and procedures (inspection intervals etc.) in which the lifts will be placed.

6.4.2 Description of Environment

Brief statement of the climatic and road environment in which the lifts will be operating.

6.4.3 Others' Experience

Request the names of three other operators with similar operations and environmental conditions for reference purposes.

6.4.4 Warranty

Lift manufacturers differ in their warranties. Unless covered under a bus manufacturer on a pass through basis the specific warranty conditions requested or offered must be clearly defined.

6.4.5 Fleet Defect

Requirement that a similar failure in 20% of the order shall constitute a fleet defect and require rectification of the whole fleet at manufacturers' expense.

6.4.6 Spare Parts Inventory

Bidder shall supply suggested inventory with projected unit and total costs for one year's operations.

6.4.7 Documentation

6.4.7.1 Manuals - Up-to-date manuals covering installation, servicing, and overhaul of mechanical, hydraulic, and electrical systems must be included with the bid.

6.4.7.2 Maintenance - Recommended maintenance procedures tailored to the operating and environmental conditions (6.4.1 and 6.4.2) should be provided.

6.4.7.3 Special Parts - The bidder should supply in conjunction with 6.3.6 a list of those components that are special or proprietary parts, those that can be rebuilt (with recommended procedures), and alternative sources.

APPENDIX A

LIFT EQUIPPED BUS OPERATORS AND DELIVERY SCHEDULES

This Appendix contains summary data on the transit properties operating (or about to operate) lift-equipped buses. This data is presented in Tables A-1 through A-7, in alphabetical order based on the lift manufacturer. The tables present a number of factors designed to give an overall picture of each bus operation and the local environment. These factors are:

POPULATION:	The population of the community,* SMSA, or service area based upon 1970 Census data.
PEAK FLEET:	The number of buses required to provide peak hour service.
MANAGEMENT:	The immediate operating management of the transit system. A = public authority M = management company on behalf of a public authority P = private sector
TEMPERATURE RANGE:	The average January minimum and July maximum temperatures in degrees Fahrenheit as a guide to the degree of climatic extremity.
PRECIPITATION:	Annual inches of rain, and snow, ice, and hail as a guide to operating conditions and possible corrosion problems.
APTA:	Membership within APTA. This is included to indicate whether this organization would be an effective channel for information dissemination.

For the major manufacturers a schedule of lift/bus deliveries, including projections for the balance of 1981 is presented in Figures A-1 through A-5, as a guide to the estimated level of experience at each site.

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* Population figures are shown in thousands.

COLLINS-CUSTOM STEP LIFT	POPULATION	PEAK FLEET	MANAGEMENT	JAN. MIN. F°	JULY MAX F°	PRECIP RAIN	PRECIP S,I,H,	APTA
MIDDLETOWN, CT	30	6	P	19°	84°	40"	40"	
GREENVILLE, NC	36	3	A	34°	91°	48"	4"	
SAN ANGELO, TX	64	5	A	34°	97°	18"	3"	
ABILENE, TX	91	8	A	33°	94°	23"	4"	
MONROE, LA	91	13	A	38°	94°	54"	0"	
MONTGOMERY, AL	139	27	A	40°	91°	52"	T	✓
STEUBENVILLE, OH	85	7	A	23°	87°	36"	36"	
LAFAYETTE, LA	78	14	A	43°	92°	59"	0"	
LEE COUNTY, FL	70	18	A	52°	91°	53"	0"	
WINCHESTER, VA	15	4	A	26°	87°	34"	30"	

TABLE A-1: OPERATORS OF BUSES WITH COLLINS CUSTOM STEP-LIFT

EEC	POPULATION	PEAK FLEET	MANAGEMENT	JAN. MIN. F°	JULY MAX F°	PRECIP RAIN	PRECIP S,I,H,	APTA
HARTFORD, CT	465	236	M	16°	84°	38"	53"	✓
HOUSTON, TX	1677	355	A	42°	94°	47"	0"	✓
DECATUR, IL	99	21	M	19°	87°	33"	22"	✓
S. MONICA, CA	88	103	A	47°	83°	14"	0"	✓
S. CRUZ, CA	73	51	A	40°	72°	31"	0"	✓
MONTEREY, CA	93	20	A	38°	70°	16"	0"	✓
CHICAGO, IL	3115	2154	A	17°	84°	29"	41"	✓
RALEIGH, NC	152	44	M	30°	88°	38"	7"	✓
CHAM-URB IL	100	33	A	19°	87°	33"	22"	✓
ANN ARBOR, MI	178	37	A	19°	83°	28"	32"	✓
TACOMA, WA	332	114	P	33°	75°	39"	15"	✓
ALBUQUERQUE, NM	297	73	A	24°	92°	7"	10"	✓
GRAND RAPIDS, MI	352	54	M	16°	83°	25"	78"	✓
LOUISVILLE, KY	739	222	A	25°	87°	41"	12"	✓
LOS ANGELES, CA	8351	2006	A	47°	83°	14"	0"	✓
SAN FRANCISCO, CA	679	423	A	46°	64°	21"	0"	✓
APPLETON, WI	129	24	A	7°	80°	23"	40"	✓
LANE TRANSIT, OR	139	41	A	32°	82°	37"	8"	✓
LAFAYETTE, IN	79	12	A	20°	85°	38"	21"	✓
BOISE, ID	85	23	M	21°	90°	10"	22"	✓
DENVER, CO	1047	452	A	16°	87°	9"	60"	✓
COLORADO SPRINGS, CO	204	28	M	16°	84°	11"	39"	✓
SALT LAKE CITY, UT	479	265	A	19°	93°	10"	58"	✓
SAN DIEGO, CA	1198	241	A	46°	75°	9"	0"	✓
N. KENTUCKY, KY	150	81	M	24°	87°	38"	19"	✓

TABLE A-2: OPERATORS OF ACCESSIBLE BUSES WITH EEC LIFTS

GMC	POPULATION	PEAK FLEET	MANAGEMENT	JAN. MIN. F°	JULY MAX F°	PRECIP RAIN	PRECIP S,I,H,	APTA
SEMTA/DETROIT, MI	3970	874	A	19°	83°	23"	32"	✓
PROVIDENCE, RI	795	198	A	21°	81°	37"	37"	✓
FAYETTEVILLE, NC	161	17	A	34°	92°	48"	4"	✓
ROCK ISLAND CTY	167	26	A	14°	85°	30"	28"	✓
WESTCHESTER CTY, NY	874	231	P	22°	85°	46"	40"	✓
VENTURA, CA	244	29	A	40°	80°	16"	20"	✓
JANESVILLE, WI	49	19	A	10°	86°	26"	38"	
COLORADO SPRINGS,CO	204	28	M	16°	84°	11"	39"	
BIRM-JEFF CTY, AL	558	157	A	34°	90°	53"	1"	
LONG BEACH, CA	344	130	A	47°	83°	14"	0"	✓
NEW ORLEANS, LA	961	386	M	44°	90°	59"	0"	✓
LANSING, MI	229	50	A	17°	83°	26"	45"	✓
SANTA CLARA, CA	1065	246	A	40°	80°	13"	0"	✓
YORK PA	123	15	A	24°	88°	38"	35"	✓
BRIDGEPORT, CT	413	36	A	22°	82°	38"	35"	✓
KALAMAZOO, MI	152	40	A	19°	86°	28"	83"	✓
WICHITA, KA	302	57	A	21°	92°	28"	16"	✓
CAMBRIA CTY, PA	96	24	A	22°	84°	43"	35"	✓
OSHKOSH, WI	55	15	A	11°	84°	25"	40"	
OMAHA, NB	491	160	A	14°	89°	33"	31"	✓
MILWAUKEE, WI	1252	513	A	11°	80°	26"	45"	✓
ORANGE CTY, CA	1421	296	A	42°	88°	16"	0"	✓
TARTA/TOLEDO, OH	487	175	A	17°	84°	28"	37"	✓
GREEN BAY, WI	129	18	A	7°	81°	23"	40"	
SEPTA/PHIL.,PA	4012	1129	A	24°	87°	39"	20"	✓
POUGHKEEPSIE, NY	102	6	A	18°	84°	39"	45"	✓
ORLANDO, FL	305	39	A	30°	92°	51"	0"	
CLEARWATER, FL	78	35	A	50°	90°	44"	0"	✓
RALEIGH, NC	152	44	A	30°	88°	44"	7"	
WILLIAMSPORT	36	8	A	21°	85°	37"	41"	✓
GARY, IN	186	90	A	17°	85°	31"	51"	✓
ERIE, PA	175	63	A	20°	80°	30"	82"	✓
SCRTD/LOS ANGELES,CA	8351	2006	A	47°	83°	14"	0"	✓

TABLE A-3: OPERATORS OF ACCESSIBLE GMC RTS SERIES BUSES

LIFT-U	POPULATION	PEAK FLEET	MANAGEMENT	JAN. MIN. F°	JULY MAX. F°	PRECIP RAIN	PRECIP S,I,H	APTA
SEATTLE, WA	1238	726	A	33°	75°	39"	15"	✓
SAN MATEO, CA	79	190	A	64°	46°	21"	0"	✓
TORRANCE, CA	134	23	A	47°	83°	13"	0"	
SUFFOLK CTY, NY	1127	60	P	26°	85°	41"	29"	✓
NORWALK, CA	86	23	A	47°	83°	14"	0"	
S. BARBARA, CA	123	52	A	47°	69°	18"	0"	✓
FAIRBANKS, AK	26	12	A	22°	72°	11"	54"	✓
MUNI, SAN FRANCISCO	716	423	A	46°	64°	21"	0"	✓
WMATA, DC	2481	1582	A	28°	88°	38"	17"	✓
EUGENE (LANE CTY),OR	139	41	A	32°	82°	37"	8"	✓
MBTA (BOSTON), MA	2652	812	A	23°	81°	37"	42"	✓
BSDA (ST. LOUIS), MO	1882	817	A	23°	88°	35"	18"	✓

TABLE A-4: OPERATORS OF LIFT-U EQUIPPED BUSES

TRANSI	POPULATION	PEAK FLEET	MANAGEMENT	JAN. MIN. F°	JULY MAX F°	PRECIP RAIN	PRECIP S,I,H,	APTA
FRANKFORT, KY	25	2	A	25°	82°	28"	16"	
OWENSBORO, KY	56	8	A	25°	87°	26"	17"	✓
PORT HURON, MI	53	5	A	19°	83°	28"	32"	
SACRAMENTO, CA	633	188	A	37°	93°	17"	0"	✓
TACOMA, WA	332	114	P	33°	75°	39"	15"	✓
LYNCHBURG, VA	71	21	M	27°	86°	38"	25"	✓
GOLDEN GATE, CA	716	236	A	46°	64°	21"	0"	✓
INDIANAPOLIS, IN	820	192	M	20°	85°	38"	21"	✓

TABLE A-5: OPERATORS OF TRANSILIFT EQUIPPED BUSES

TDT	POPULATION	PEAK FLEET	MANAGEMENT	JAN. MIN. F°	JULY MAX F°	PRECIP RAIN	PRECIP S,I,H,	APTA
SCRTD/LOS ANGELES,CA	8351	2006	A	47°	83°	14"	0"	✓
SAN MATEO, CA	556	190	A	64°	46°	21"	0"	✓
SANTA CRUZ, CA	73	71	A	40°	72°	31"	0"	✓
SEATTLE, WA	1238	726	A	33°	75°	39"	15"	✓
CANTON, OH	244	75	A	20°	83°	33"	36"	✓
SEPTA/PHIL. PA	4026	1129	A	24°	87°	39"	20"	✓
WACO, TX	118	13	M	32°	98°	26"	1"	✓
SAGINAW, MI	147	18	M	19°	83°	28"	32"	✓
COLUMBIA, MO	59	14	A	21°	90°	35"	19"	✓
BAY CITY, MI	78	25	A	18°	84°	24"	40"	✓
LOUISVILLE, KY	739	222	A	25°	87°	41"	17"	✓
W.PALM BEACH, FL	287	61	M	58°	91°	62"	0"	✓
BROWNSVILLE, TX	53	12	A	52°	93°	27"	0"	
LAREDO, TX	70	16	M	46°	100°	19"	0"	✓
VANDALIA, OH	11	2	A	15°	88°	31"	28"	✓
DAVENPORT, IA	100	20	A	14°	88°	30"	28"	✓
MARION, IN	40	4		21°	88°	35"	25"	
BLOOMINGTON, IL	69	18	A	18°	87°	33"	22"	
GALESBURG, IL	36	2	P	17°	88°	32"	22"	
QUINCY, IL	45	6	A	20°	90°	33"	22"	
BLOOMINGTON, IL	69	18	A	18°	87°	33"	22"	
SAN DIEGO, CA	1198	241	A	45°	77°	10"	0"	
ATLANTA, GA	1172	738	A	37°	87°	47"	2"	

TABLE A-6: OPERATORS OF ACCESSIBLE BUSES EQUIPPED WITH TDT LIFTS

VAPOR	POPULATION	PEAK FLEET	MANAGEMENT	JAN. MIN. F°	JULY MAX F°	PRECIP RAIN	PRECIP S,I,H,	APTA
MILWAUKEE, WI	1252	513	A	11°	80°	26"	45"	✓
WMATA, DC	2481	1582	A	28°	88°	38"	17"	✓
AUSTIN, TX	264	53	M	41°	95°	33"	1"	✓
S. BERNADINO, CA	583	68	M	38°	95°	18"	0"	
BANNING, CA	12	1	A	42°	88°	16"	0"	
WALNUT CRK, CA	40	3	A	34°	84°	20"	0"	✓
ALBANY, OR	30	3	M	32°	83°	39"	1"	
JOHNSON CITY, TN	34	8	A	31	89°	40"	10"	✓
INDIANAPOLIS, IN	820	192	M	20	85°	38"	21"	✓
WICHITA, KA	302	57	A	21	92°	28"	16"	✓
KALAMAZOO, MI	152	40	A	19	86°	28"	80"	✓
NORWOOD, OH	35	5	A	25	87°	37"	17"	
NEW ORLEANS, LA	961	386	M	44	90°	59"	0"	✓
LIVERMORE, CA	38	5	A	36	88°	14"	0"	✓
OAKLAND, CA	1640	712	A	41	73°	18"	0"	✓
SYRACUSE, NY	376	167	A	17	82°	27"	109"	✓
LOUISVILLE, KY	739	222	A	25	87°	41"	17"	✓
SAN MATEO, CA	556	190	A	46	64°	21"	0"	✓
PORTLAND, OR	824	475	A	35	79°	39"	1"	✓
ATLANTA, GA	1172	738	A	37	87°	47"	2"	✓

TABLE A-7: OPERATORS OF BUSES EQUIPPED WITH VAPOR TRAVELIFTS

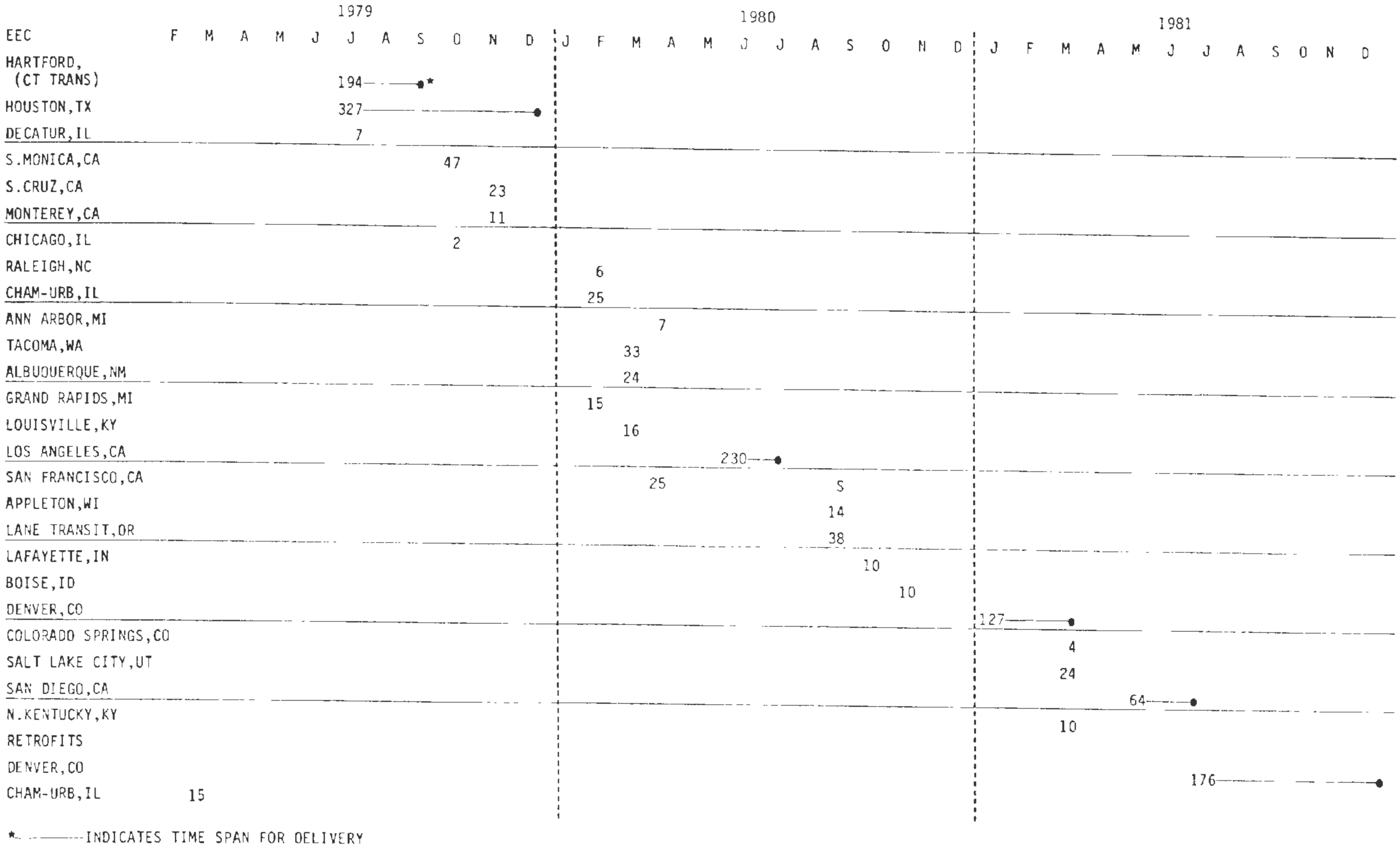

FIGURE A-1: SCHEDULED DELIVERIES OF BUSES EQUIPPED WITH EEC LIFTS

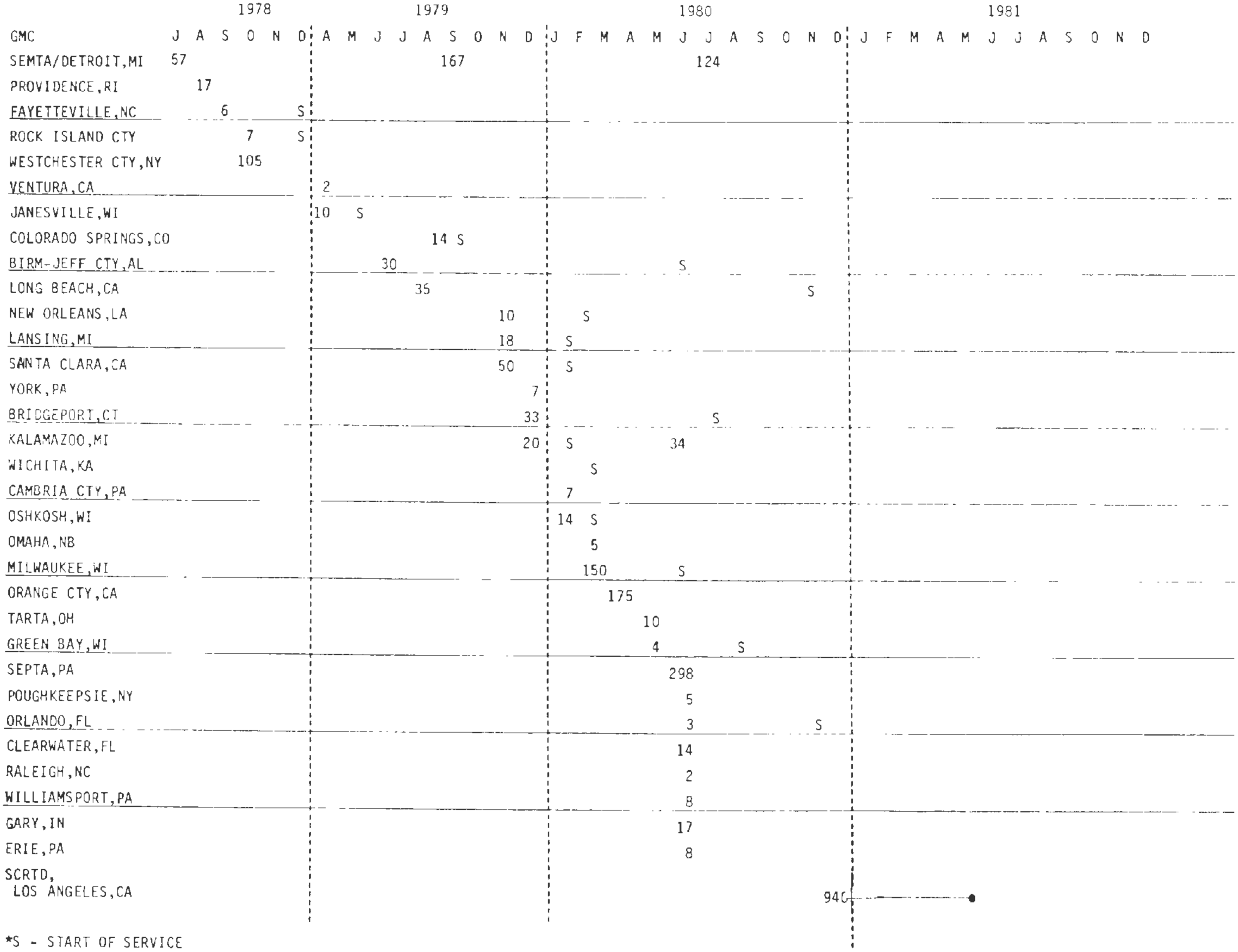

FIGURE A-2: DELIVERY SCHEDULE OF ACCESSIBLE GMC RTS SERIES BUSES

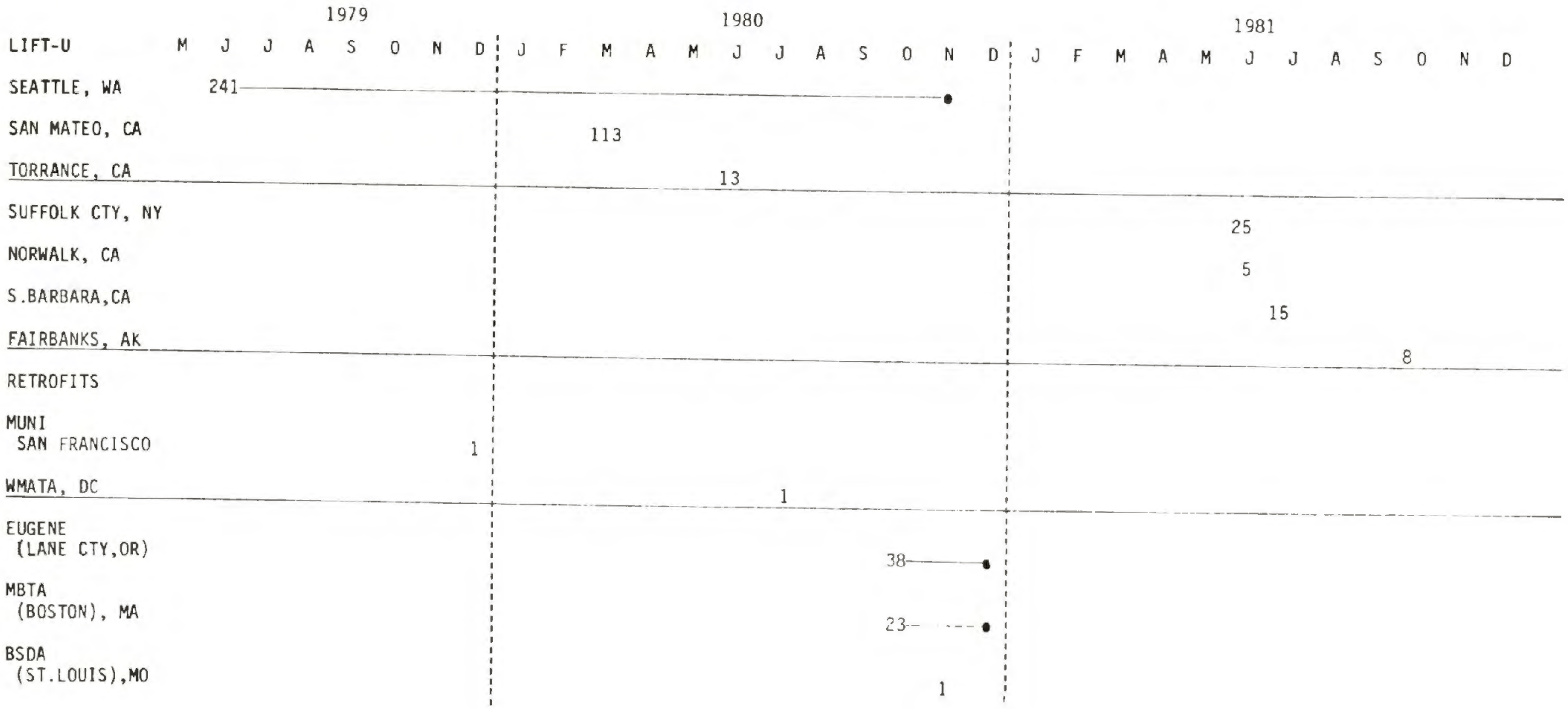

FIGURE A-3: SCHEDULED DELIVERIES OF LIFT-U EQUIPPED BUSES

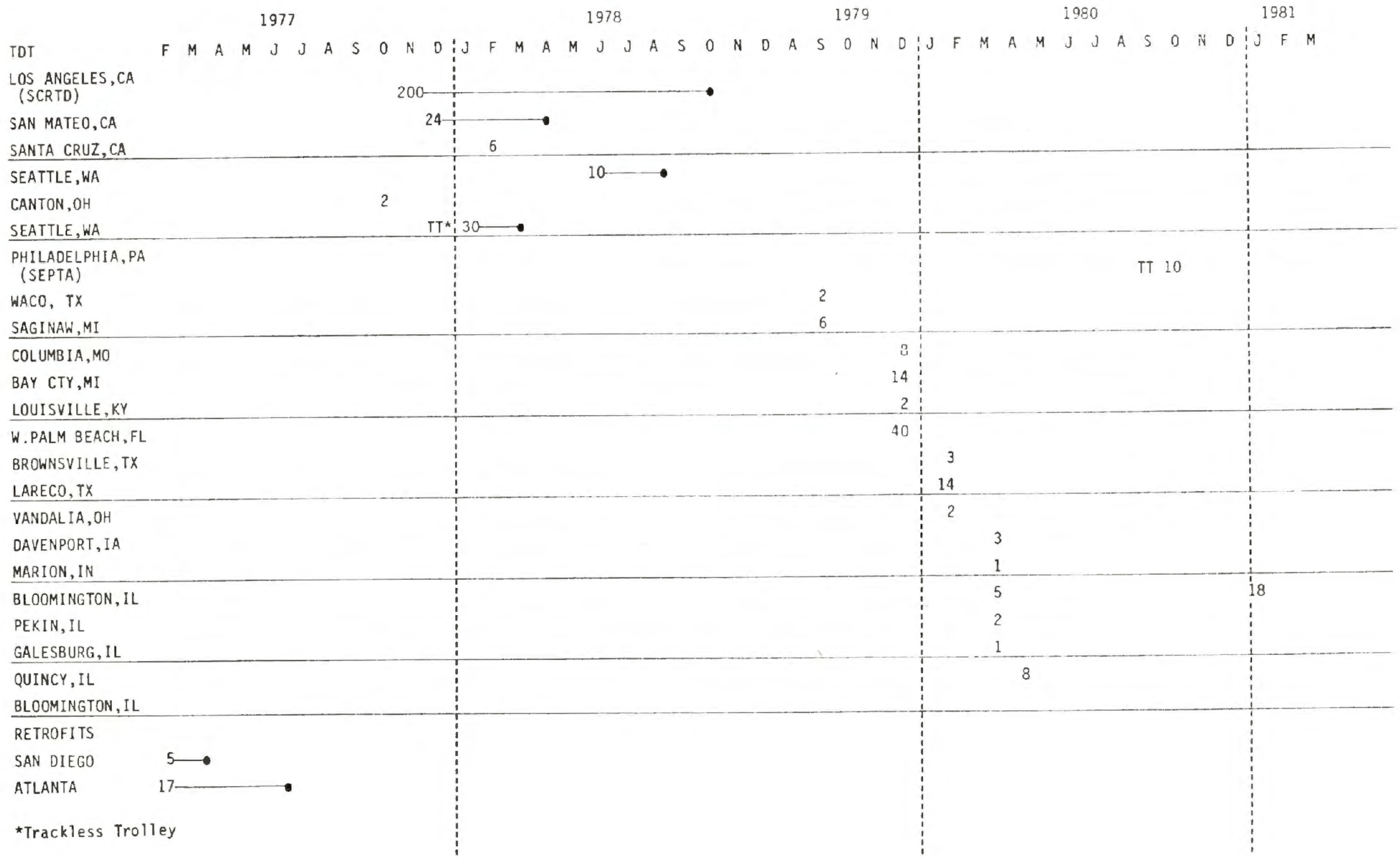

FIGURE A-4: SCHEDULED DELIVERIES OF TDT LIFT EQUIPPED BUSES

☆ U. S. GOVERNMENT PRINTING OFFICE: 1983--600-816--362

	1978											1979									1980										1981							
VAPOR	F	M	A	M	J	J	A	S	O	N	D	A	M	J	J	A	S	O	N	D	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
MILWAUKEE,WI				100																																		
WMATA,DC								151																														
AUSTIN,TX	5																																					
S.BERNADINO,CA								7																														
BANNING,CA											2																											
WALNUT CRK,CA											6		4																									
ALBANY,OR												3																										
JOHNSON CITY,TN															3																							
INDIANAPOLIS,IN																				2																		
WICHITA,KA																						5																
KALAMAZOO,MI																							8															
NORWOOD,OH																									3													
UCAL,(BERK),CA																										1												
NEW ORLEANS,LA																													6									
LIVERMORE,CA																														6								
OAKLAND,CA																													175				o					
SYRACUSE,NY																																			25			
LOUISVILLE,KY																																	15					
SAN MATEO,CA																																					10	
PORTLAND,OR																																						
ATLANTA,GA																																					50	

FIGURE A-5: SCHEDULED DELIVERIES OF BUSES WITH VAPOR TRAVELIFTS