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KCMR DIAL-A-RIDE STUDY: REPORT NO. 4

VEHICLES, MAINTENANCE, FARE COLLECTION

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FOR THE MID-AMERICA REGIONAL COUNCIL

BY THE HURON RIVER GROUP, INC./MISSOURI TRANSPORTATION ASSOCIATES

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This report contains findings and recommendations of the consultant study team to the Mid-America Regional Council and does not necessarily reflect the position of the Council, the Urban Mass Transportation Administration, or any participant or sponsoring group.

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I. VEHICLES FOR DIAL-A-RIDE USE

Vehicle Types

Dial-A-Ride service calls for smaller vehicles than conventional transit buses because average and peak passenger loads are much smaller, and because they are used in residential service.

Conventional U.S. and Canadian large urban transit buses are generally standardized at 35 or 40 feet long, 96 or 102 inches wide, and seat 42-53 adult passengers at maximum seat density with a two-door configuration. In the simplest definition, any vehicle smaller than this size range is a "small bus". This definition includes virtually a continuum of currently available vehicles, from 16 ft./10 passenger vans to 30 ft./31 passenger "small transit buses", and a wide diversity of configurations. This market situation is a recent phenomenon, with few basic designs older than seven years.

Because currently offered vehicles come in a continuum of sizes, and because no clear indication of a consensus among users exists as to functional distrinction within the size range indicated, it is very difficult to classify small buses except by configuration (i.e., chassis layout and percentage). Such a classification corresponds roughly to sizes as well, and is useful as a description of the current situation. It does not necessarily reflect an ideal typology, however. The usual chassis type now associated with a size range does not represent the end point of a lenghtly technological evaluation toward a best technical answer to the demands on a vehicle of that size in public transportation operation. With that caveat, small buses* can roughly be classified as follows:

Chassis Type	Typical Length (ft.)	Typical Pass. Capacity	Typical 1976 Price ($)
Automotive (compact van)	16-18	10-15	7000-16000
Medium duty truck/motor home/school bus	19-25	16-25	21000-28000
Transit-type Rear engine	25-30	25-33	50000-60000

*Not included in this classification are small battery electric buses, which have uniquely specialized application and are no longer in production in any case.

The last, largest type generally resembles shortened versions of standard large transit coaches. While markedly different from the other vehicle types in configuration and price, vehicles of this class are frequently considered by transit operators as directly competitive with smaller vehicles for use in almost all potential small bus applications.

In contrast, taxi operators often prefer to use standard 4-door sedans for Dial-A-Ride or shared-ride service. While average vehicle occupancy in Dial-A-Ride is quite low (2-3 passengers), peak loads in high-productivity use often exceed 10 passengers. We recommend against use of conventional automobiles for Dial-A-Ride primarily for that reason.

Reliability and Useful Vehicle Life

Urban Dial-A-Ride usage of small buses, with frequent stops and occasional long periods of idling, is an exceptionally severe operating environment. The durability of many vehicle components has been less than desired by many operators, especially transit operators accustomed to buses engineered specifically for such a duty cycle. Related to these concerns is that of useful vehicle life, which is less for most classes of small buses than the 10-15 year typical life of large transit buses.

Recurrent mechanical problem areas in small bus use have been in brakes, transmission, and electrical systems. No vehicle subsystem has been devoid of significant problems, however. Contributory factors to the occurrence of these problems have been:

1. Poor specifications issued by purchasers
2. Insufficient engineering, materials and quality control by manufacturers, especially for a very severe operating environment
3. Inexperience of many operators in small bus maintenance

Incremental, evolutionary progress has been made in all three of these areas over the last several years.

Aside from durability issues, a number of basic design deficiencies are commonly noted in existing small buses. It can be difficult to differentiate between some durability issues and design elements, in that most small buses owe their comparatively low prices to the fact that they utilize mass production chassis and running gear which limit design freedom. Poor service access and compromises in space efficiency are examples of design problems which can be alleviated but not completely solved in a front-engine configuration.

Use of a diesel rather than gasoline engine in a particular vehicle is a frequently expressed desire, usually based in an expectation that longer useful vehicle life would result at low marginal cost. This perception is not necessarily accurate on at least two bases:

- Diesel power does not automatically equate to high durability and longevity. Many smaller diesel engines are not designed to the long-life standards of transit and heavy truck use, and have service lifetimes similar to or slightly greater than conventional gasoline engines.
- Fitting a diesel engine to a pre-existing vehicle is a difficult engineering feat, and should include substantial other changes. The increased weight of a diesel engine can aggravate other drivetrain and braking problems, requiring extensive modifications.

The most compelling argument for diesel power is the savings from greater fuel economy in urban use. Given that many significant applications of small buses are in smaller cities with small fleets, the specialized maintenance and inventory required should be carefully considered in evaluating the desirability of diesel power. Further, the characteristically higher noise level and diesel odor can be deterrents to diesel use in buses serving residential areas.

Poor human factors design, especially in the driver's compartment, is shown in many current offerings. Poor outward visibility, seat positioning, and controls layout are inexcusably common. Clean and modern exterior design is surprisingly rare for vehicles of mostly recent design. Contrasted to these flaws is the fact that most small buses offer wheelchair lifts, and some offer superior passenger access arrangements to the current generation of standard transit buses.

The issue of vehicle lifetime has suffered from much misinformation, especially in a lack of general recognition that different vehicle components have inherently different lifetimes. The major point usually made is that the gasoline engine of the typical small bus has an expected life (to rebuilding) of approximately 100,000 miles. This is contrasted to the large bus diesel engine expected life of 350,000 or more miles to rebuilding. Not commonly recognized is that replacement gasoline engines can be fitted at remarkably low cost to a body and frame structure which are still basically sound.

Alternately, a sound bus body can be lifted completely off a worn chassis and replaced on a new one at a small fraction of the original vehicle cost. Many of the truck-based "intermediate" small buses are built in a way which allows such a procedure, and have bodies sufficiently well constructed of corrosion-resistent materials. The concept of a unitary vehicle life becomes difficult to maintain in the light of such procedures.

Most vans are built with a unitized body-framestructure which precludes such an arrangement. It remains to be seen whether the highly reinforced body structure of some modified vans will be of long enough life to allow economic renewal of running gear. Modified vans without heavy body reinforcement probably do not have a body life expectancy sufficient to justify major mechanical renovation.

Without attempting to adjust for these factors, typically quoted useful lifetimes and sample yearly capital costs for various classes of small buses are:

Vehicle Type	Initial Cost	Typical Life*	Annual Capital Cost
Low-cost van-based	$ 9,000	3	$3000
High-cost van-based	$15,000	3-4	$3650-5000
Truck-based	$24,000	4-6	$4000-6000
30-foot transit	$55,000	8-10	$5500-6875

*In years, for transit use at 30,000 - 50,000 miles per year.

The range of annual capital costs shown indicates on a simple basis that smaller vehicles may be more capital-efficient (if operations do not require higher passenger capacities), even allowing for their shorter useful lifetimes.

The calculation above does not represent the full picture, however, because two or more generations of smaller vehicles are needed to cover the total life of a larger vehicle. If inflation increases the future prices of replacement smaller vehicles, the 8-10 year total capital cost advantage of smaller vehicles is reduced. With the figures tabulated above, the latter three classes of vehicles have essentially equal ten-year capital costs with a seven percent annual inflation rate (compounded), assuming three generations of van-based buses and two generations of truck-based buses over the life of one small transit coach.

Other factors such as intensity of immediate capital needs, operating cost and flexibility, ability to incorporate new design features more rapidly, and such have important impacts on any full calculation of ten-year costs. Operating costs are subject to dispute, but generally are lower for smaller vehicles.

Van-Based Vehicles

Van-based small buses exhibit great variety, including:

1) Standard manufacturer's vans (Dodge/Plymouth, Chevrolet/GMC, Ford) unmodified except for various mass market options.

2) Vans modified for school bus use, with strengthened standard-width (6'8") body structure, moderate heavy running gear, 63" headroom roof cap, driver-operated passenger door, and usually a wheelchair lift option.

3) Vans modified with adult-headroom roof caps and a variety of driver-operated doors, similar in outside appearance to camper vans. These are available with essentially unmodified basic body structure and also with extensively strengthened bodies, with several varieties of fiberglass, fiberglass over steel tubing, and all steel roof caps.

Basic body width is standard. A variety of wheelchair lift options are available.

4) Vans similar to those above, but with body width also increased to approximately 8 feet.

Most van conversions are available on any of the three major manufacturers' chassis. Because of its larger basic body shell, the Dodge/Plymouth maxivan series is most commonly used for Dial-A-Ride conversions.

The State of Michigan, Bureau of Urban and Public Transportation, and several larger transit operators in Michigan have purchased over 300 small buses over the last 3 years and have developed a substantial body of documented operational history on almost all available van-based and truck-based vehicles. The State routinely purchases vehicles in relatively large bid lots and distributes them to operators, and has carried out a program of experimental purchase and evaluation of a few of each major vehicle type on the market.*

The standard Dial-A-Ride vehicle in Michigan is a moderate to high-cost converted van. The higher-cost versions, with extensive strengthening of the body structure, are used in larger urban systems. Small-city Dial-A-Ride systems usually have one or two truck-based vehicles for larger groups, with the bulk of their vehicles being moderate-cost van conversions. Both the State and the Ann Arbor Transportation Authority have expended considerable effort in developing successive generations of van conversion specifications, incorporating refinements to improve operating reliability and reduce maintenance costs.

Truck - Based Vehicles

The largest group of small buses available is composed of intermediate size vehicles, built over medium duty truck or truck-related forward-engine chassis. Body materials include steel, fiberglass, aluminum, and various combinations of these.

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*Bureau of Urban and Public Transportation, State of Michigan Small Bus Program Vehicle Operation Efficiency Report (1975) and Michigan DART Program Status Report (1976) contain specification, maintenance, and operating cost information on these vehicles. Both reports are available in the MARC library.

Most offer seating and features options similar to large buses, as well as wheelchair lift options. Vehicles of this type are familiar as small, boxy schoolbuses and as the inter-terminal shuttle buses at KCI Airport.

Engine type, suspension, braking, and transmission generally follow standard truck/motor home/school bus practice rather than large transit buses, as compared below:

	Most "Intermediate" Small Buses	Standard Transit Bus
Engine Type	Gasoline	Diesel
Suspension	Steel Springs	Air
Brakes	Vacuum-assist power	Air
Transmission	Standard truck 3-speed automatic	Special design 2-speed automatic

The Mercedes 0309D falls in this class by size, forward engine/ladder truck-type frame configuration, and steel spring suspension, but uses a small diesel engine and air brakes. The Mercedes transmission is a four-speed automatic similar to that used in heavier trucks. Although slightly smaller than other vehicles in this class, these features of the Mercedes place it well above the other vehicles in price.

A bus version of the unusual GMC Motor Home is available which does not clearly fit in either truck-based or small transit bus classes. It is intermediate in size and price between the two groups, and has an extremely low floor, front-wheel drive, and air suspension on tandem rear wheels. Kansas City, Kansas has acquired three of these vehicles for neighborhood service.

Small Transit Buses

Three manufacturers offer buses of roughly 30 feet in length which generally use design features and/or components of large transit buses. Diesel, gasoline, or propane engine options are usually available, all rear-mounted. Two of the three offer wheelchair lifts.

They are marketed as long-life, high durability transit vehicles. However, the service record of at least one such vehicle (Twin Coach) has been very poor. A smaller (25-foot) version of the Twin Coach has been extensively used in demand-responsive transit service. Strong transit operator interest in a relatively small vehicle with basic design and component specifications similar to large transit coaches has been blunted by the problems and high operating cost of this vehicle type. It seems likely that engineering development can remedy these problems if the resources can be applied to the situation. Such an outcome is in doubt, however, because the manufacturer is currently in reorganization under the threat of bankruptcy.

Two large transit operators have recently taken a novel approach to obtaining a 30-foot transit bus in reaction to these problems and high prices for current new vehicles. They have cut apart older 35-foot buses, removing a five-foot section from the middle of the vehicle, and reattaching the two ends, followed by an extensive reconditioning. Specifications for a new generation of standard 30-foot buses have been developed by the Urban Mass Transportation Administration and the transit industry, but have not yet resulted in a production vehicle.

2. CONSIDERATIONS IN VEHICLE ACQUISITION

The Procurement Process

Purchasing buses that are appropriate for the service they will be asked to perform and are reliable with low maintenance costs is a difficult, time-consuming, highly technical process. Fleet operators of all types sometimes seem to be nearly obsessed with obscure details of specifications, reliability, and maintenance. Generally, however, their concerns are well-placed. Poorly performing vehicles can have profound effects on the operation of a system, the morale of its personnel, and its perception by the riding public. These effects go far beyond issues of vehicle maintenance cost, which is a fairly minor component of Dial-A-Ride system cost.

Public agencies using grant funds are usually required to issue detailed specifications and purchase from the lowest responsive bidder. All too common practice in issuing specifications has been for the operator to write them tightly in conformance to a particular supplier's product, chosen in advance. Rather than allowing price and quality competition within the bid process, this procedure moves the arena of competition into attempts to influence specification writing. The procurement process under these conditions becomes an elaborate game with largely unwritten rules, with some checks and balances provided by granting agency specification reviews and protests from rejected suppliers.

Historically, most purchases of small buses have been for small numbers of vehicles in any single procurement, frequently only one or two at a time. The combination of small volumes in particular procurements and the complex specification and bid process entails rather high marketing costs for suppliers. In addition, suppliers not accustomed to the process tend to be overwhelmed if very detailed specifications are issued. This is especially true of manufacturers that deal through local distributors or retailers who are often relatively ignorant of product details.

Because available small buses are so diverse, however, it is difficult to write specifications that can attract competitive bids for closely comparable products, especially if prior analysis indicates that the probable best vehicle is a unique product such as the Mercedes 0309D or the GMC Small Bus. The result of all these factors is that a fair process of vehicle acquisition will involve a great deal of effort by the purchaser to understand the details of the vehicles being offered and their relationship to system needs. Careful evaluation of all bids received on a value-for-cost basis may be necessary, together with the possibility of justifying purchase from other than the low bidder.

The procurement process should start with identification of the type or types of vehicles to be purchased, by size and price range. The proper vehicle is the smallest that will do the job. If an occasional need for a larger capacity bus is foreseen, provision of one or two larger vehicles should suffice. On the other hand, there is virtue in keeping the variety of system vehicles within bounds. Two or at most three different types should cover the spectrum of needs without introducing unmanageable inventory and maintenance problems.

Specifications should be developed with great care, considering the issues discussed below and using the experience of other operators to the greatest possible extent. After the specifications are distributed to prospective suppliers, an opportunity should be provided for vendor exceptions, and amendments to the specifications should be considered. UMTA concurrence in specifications will be required if Federal funds are involved. When bids are received, they should be analyzed very carefully for compliance with specifications, comparative option prices, projected operating costs, etc. After award, the purchaser should expect to work closely with the supplier, inspecting for construction quality if possible and resolving and clarifying minor points that inevitably arise. Acceptance testing is mandatory. The whole process should be minutely documented. Unfortunately, no supplier can simply be trusted to deliver vehicles exactly as specified and bid; a high level of attention throughout the process is the only way to guarantee complete compliance.

Common pitfalls in this process include:

- Over-concentration on deluxe trim items in specifications. While spartan and unattractive passenger non-amenities should be avoided, repeated studies have shown that passengers are much less sensitive to the higher ranges of interior luxury than intuition suggests.
- Compromises in basic durability because of time pressure. Availability of chassis properly specified for severe duty is usually the critical factor in delivery time. It is much better to lease or borrow vehicles for interim operation than to accept other than the heaviest-duty chassis as specified.
- Overly stringent bid and performance bonds, restrictions, and special requirements. The costs of excessive paperwork and bonding are simply built into bid prices and seldom add real security. They cannot substitute for close monitoring by the purchaser.
- Large departures from manufacturers' standard products and excessive nuisance items such as complex painting patterns and miscellaneous add-on gadgets. Specifications should be aimed at proven standard vehicles which most closely meet system needs, rather than calling for special modifications. Small add-on items can usually be fitted at lower cost by the purchaser after vehicle delivery.

Leasing

Leasing of vehicles can be an attractive way of controlling costs and reducing the risk that equipment will be purchased for a program that may later be discontinued. It also provides a way to try out vehicle types which are candidates for later purchase or to begin service with interim equipment when delivery of specified vehicles may take longer than desired.

Leasing is only available, however, for a few of the vehicles on the market. Most small buses are built to order, for a very limited primary purchase market. The market for used equipment is even more limited. Vehicles available for lease generally include only unmodified vans, Mercedes buses, and occasionally demonstration models of some other types.

Specification Guidelines

The principal focus of this discussion is the adequate specification of van-based and truck-based small buses for urban Dial-A-Ride use. These vehicles have the potential of giving excellent service with low cost, but only if the purchaser demands the highest standards of chassis engineering and quality control. Small transit buses present a somewhat different set of highly technical problems, and are not recommended for Dial-A-Ride use.

Specific materials standards, dimensions, equipment model numbers, etc. are best obtained from detailed specifications issued by experienced operators.* The latest product specifications should also be requested from potential suppliers to assist in development of such details, since they change continually. Federal regulations pertaining to elderly and handicapped persons should be consulted. While buses of less than 22 feet in length are not specifically covered, their intent and spirit will be considered in specification approval for small buses. Recommended features and areas of concern are as follows:

Vehicle Component	Comments/Recommended Features
1. Body structure	. Vans must have heavy steel reinforcement integrating lower body and roof cap; fiberglass roof without extensive steel framework not acceptable. Must meet School Bus Mfr's. Std. No. 002 and Federal Safety Standards. . Non-corroding materials and/or full rust-proofing, not just undercoating. . Extensive insulation mandatory.

*Current Michigan versions are available at MARC.

Vehicle Component	Comments/Recommended Features
2. Suspension, Steering, General Chassis	. Suspension must be special super-duty package available only by special factory order, but not always listed in dealers' option catalogs: includes HD* shocks, high-capacity springs and axles, special bearings.
	. HD power steering.
	. HD wheels and largest radial tires
	. All components elaborately protected from corrosion, spray, and road dirt.
	. Highest quality tubing and fittings.
	. Component accessibility must be assured.
3. Drivetrain	. HD truck engine.
	. Highest capacity radiator and maximum size fan.
	. HD transmission with oil cooder.
	. HD differential.
4. Electrical	. Highest capacity alternator and battery.
	. Special wiring for conversion or body is a critical area--must be extremely carefully done; with wiring diagram provided.
	. Extra fuses and circuits must be provided; no additional use of standard circuits
	. 4-way flasher must be independent of brake lights; HD flasher.
	. Special wiring harness for mobile 2-way radio should be factory installed if possible.

*HD = Heavy Duty

Vehicle Component	Comments/Recommended Features
5. Brakes	. Part of mfr's. special super-duty package--mandatory.
	. Electromagnetic brake retarder recommended for truck-based buses (not justified for vans).
6. Fuel System	. Dual filters required.
	. Minimum 35 gal. fuel tank (vans); extremely important to allow fuel day's operation without refueling.
7. Passenger Door and Entry	. Extending auxiliary step; careful design of tread depth and step heights.
	. Grabrails provided both sides.
	. Door-actuated stepwell light.
	. Double-width (54") door if possible; maximum width entryway.
8. Passenger Safety and Amenities	. All interior surfaces padded and protected, including grabrails and stanchions.
	. Forward-facing low-back seats with grabhandles
	. Tinted push-out safety windows.
	. Fire-resistant materials.
	. Emergency exit provision, sides and rear.
	. No seat belts (never used).
	. Interior lighting, driver controlled.
	. Parcel racks or areas are seldom used.
	. High-capacity air conditioning and dual heater
9. Driver's Compartment	. Special transit-type fully-adjustable seat; standard van seat not acceptable.

Vehicle Component	Comments/Recommended Features
	. Well-designed dash and controls layout, full gauges, lighted special switches, durable construction.
	. Provision for clipboard, pencils, misc. items.
	. Special lighting for driver.
10. Miscellaneous	. Spare tire and jack recommended <u>only</u> for rural use.
	. Fire extinguisher, flares, first aid: specific provisions for safe storage and easy access.
	. Passenger signaling system.
	. Destination signs, easily changed by driver.

Finally, manufacturers should be required to test vehicles individually for watertight construction and to assure that all subsystems are working perfectly. Full payment should be made contingent not only on careful inspection upon delivery by the purchaser but also on 1-2 days of trouble-free revenue service if at all possible.

Provision for Wheelchairs

Handicapped passengers in wheelchairs require special design attention to allow a ramp or lift and appropriate tie-down spaces. Guidelines for such installations are:

- A side-mounted rather than rear-mounted lift is recommended to facilitate curbside boarding and debarking.
- Experience has shown that two or three tie-down positions are the most needed in almost all applications. Standard passenger seats should fill the balance of the vehicle, both for vehicle use in other service and for non-handicapped family members, attendants, etc. who should often accompany the handicapped.
- Ready access to the rear emergency door is of the greatest importance. The aisle should be free of obstructing seats across the back to preserve an emergency exit in the event the bus is in an accident and comes to a stop on its right side.

- Ramps are feasible only if the vehicle floor is quite low or if only a very small number of passengers is ever expected to be carried. In general, lifts are preferred.
- The lift platform should be large enough to give the passenger a sense of security when being raised. A sensation of being in mid-air with no visible support is very frightening. Lifts which swing around a single pivot are unacceptable. Wheelcups or channels, etc. should be provided to minimize the possibility of wheelchair movement if the platform cannot be perfectly horizontal.
- The height of the opening through which wheelchairs are to pass should be sufficient so that passengers do not need to duck. This is not the case with standard van side cargo doors.
- The duty cycle for lifts used in public service is very severe compared to that characteristic of private use. The lift should be designed to cycle up and down over 50 times per operating day with high reliability. The lift itself will generally cost $1,200 or more uninstalled. Installed option prices should be expected to be from $1,500 up to $7,500, depending on the amount of work necessary on the vehicle body.
- The lift must, of course, operate smoothly and adjust to various levels from street level to that of high curbs so wheelchairs will be able to roll onto the lift.
- Several manufacturers are now offering convertible stairway/lift combinations that serve as regular stairs and can unfold to form a lift platform. This is a highly interesting design, but operating reliability and experience should be checked.
- Lifts impose a very heavy drain on the battery and alternator. An interlock to prevent raising the lift without the vehicle running prevents dead batteries. It should be possible to lower the lift at any time.

- Wheelchair fastening mechanisms should be simple and reliable in operation, and should be supplemented with special seatbelts for wheelchair passengers.
- Positioning wheelchairs in the bus with the passenger facing to the side is acceptable but not the best. Starting, stopping, accelerating, and decelerating all have a magnified effect on people facing sideways--particularly handicapped passengers. Locking the wheelchair in a forward-facing position or at an angle of from 45 to 60 degrees from facing forward is better.
- It should be recognized that most wheelchairs are very fragile and present a hazard in case of accident. Elaborate attempts to assure that the wheelchair remains fixed in place under high stresses will likely result in only pieces of wheelchairs being securely held. The passenger needs to be securely held, not the chair.
- Carrying a spare folding wheelchair in each vehicle is a real help to those with walkers, etc. for whom lift use is relatively awkward.

3. MAINTENANCE ORGANIZATION

Functions

Proper vehicle maintenance requires attention to four functions:

- Daily fueling, cleaning, checking, and revenue processing
- Scheduled inspections and preventive maintenance
- Heavy maintenance and repair, including mechanical, electrical, and body work
- Emergency road service

All of these functions also have an extremely important record-keeping and inventory maintenance/purchasing component, which can be thought of as a fifth function.

Small Operation: Contract Maintenance

In very small operations (around 5 vehicles), only daily checking and basic record-keeping are generally appropriate for in-house performance. In these cases, a single person--usually the project manager, but possibly a mechanically-inclined driver--should have undivided responsibility for coordinating maintenance and keeping records. In such small operations, it is often desirable to have drivers perform routine daily vehicle checks. This procedure (checking oil, radiator coolant, battery, transmission fluid, and lights) takes a minimum of time, but it assures that basic systems are in working order and keeps drivers conscious of the condition of the vehicles. More often, a single part-time individual performs the cleaning and checking functions for all vehicles, at the end of each service day. A basic inventory of fluids, light bulbs, cleaning supplies, and minor parts should be maintained for these functions, along with some simple hand tools.

Transit vehicles get surprisingly dirty in just a day of operation. To convey a clean, efficient image to the public, the operator should make provisions to wash vehicles and clean interiors <u>daily</u>. Mechanical drive-through bus washers are commercially available for large operations, but most paratransit operators find manual hand washing preferable. A durable wet/dry shop vacuum allows much better interior cleaning than brooms. Cheap, high school student labor is usually readily available.

Indoor, secure storage for vehicles is the best, but it is sometimes not practical. Diesel powered vehicles are especially difficult to start in cold weather; covered, heated storage helps. If the operator must use outdoor storage in a high crime area, a fence would be desirable to discourage vandalism. An unused gas station is an ideal operating headquarters for a system of this size, providing capability for fuel storage and pumping and indoor washing.

Inspections, routine and heavy maintenance, and road service for such small operations are most economically performed by arrangements with a municipal or large transit system garage, and/or arrangements with a private auto repair shop or dealership. Considerations in making such arrangements are:

- labor cost
- ability to assign high priority to minimize down time, including overnight work
- reputation and adequacy of equipment and facilities
- deadhead distance

The person in the system responsible for vehicle maintenance coordination should have a close working liaison with both supervisors and mechanics in the shop or shops used for system vehicles. The type of maintenance shop which most commonly provides the best all-around service is the private maintenance organization specializing in medium and heavy-duty trucks. Moderate additional cost can be justified if such a shop can be more responsive to system needs. A specific contract for maintenance service may be desirable but is not mandatory; storage can sometimes be arranged with the same organization.

In-House Maintenance

Operations with 10-20 vehicles usually find it advantageous to do more maintenance in-house, although contracted services often remain highly satisfactory at this level. Development of in-house maintenance is a major step, requiring a quantum jump in equipment and inventory investment of $4,000 or more. Appropriate maintenance staff for a 15-bus operation is usually about four, as follows:

- One maintenance coordinator/supervisor, responsible for scheduling, record-keeping, primary liaison with drivers and outside shops, purchasing and inventory. Should be able to diagnose and trouble-shoot minor problems and understand major maintenance procedures.
- Two mechanics on overlapping day/evening shifts, with differing specializations. One may be a lower-skill mechanic's helper.
- One cleaner/checker/janitor/mechanic's helper for cleaning, parts running, and miscellaneous tasks. May also serve as a night watchman.

A substantial equipment investment is required to utilize mechanics' skills effectively, including:

- benches and storage facilities
- grinder, lathe, drills
- engine diagnostic equipment
- jacks and stands
- air compressor, hosing, and tools
- wheel mounting/balancing equipment
- bulk fluid equipment
- battery charger
- parts cleaning equipment
- misc. special tools and gauges
- service truck

Other infrastructure elements that begin to become appropriate at this level are a larger facility with two service bays and a parts inventory including a ready-to-run spare engine and transmission, tires, spare carburetors and similar items. A pressure spray washer is also justified at this point.

Specialized maintenance functions such as transmission rebuilding, complex electrical work, and body work are still often done by outside shops. Further growth in system size above 20 buses adds maintenance staff with greater specialization and begins to achieve economies of scale. Radio system maintenance must be done by licensed technicians and is only appropriate in-house for very large Dial-A-Ride systems of at least 50 vehicles.

Preventive Maintenance

Inspections and basic elements of preventive maintenance should be scheduled more frequently than manufacturers' recommendations for standard service. A basic servicing interval of 3,000 miles, or about once a month, is a good starting point for a thorough mechanic's check of all vehicle subsystems. Service life records of frequently replaced components and needs, such as brake linings and transmission adjustments, should be kept as guides for replacement needs. The goal of the 3,000-mile inspection process should be to ensure that nothing in the vehicle will require other than routine daily servicing until the next inspection. Marginal parts should thus be replaced if it is likely that they will wear out over that interval.

Whether mechanical work is done outside or in-house, the most critical part of effective preventive maintenance is accurate and complete record-keeping. Complete systems for this function are widely available from vehicle manufacturers' fleet service departments and other sources. They should be used in even the smallest system. Further discussion of this topic in relation to other Dial-A-Ride system records is found in Report No. 5 of this series.

Particular vehicle types invariably show relatively weak and strong points. Replacement of brake linings is typically required more frequently in Dial-A-Ride vehicles than most mechanics regard as desirable. An effective maintenance program will identify and compensate for such features of the vehicle and its operating environment with minimum down time.

4. FARE COLLECTION

Functions and Equipment

Transit fare collection equipment has been called upon to satisfy two basic functions: (1) to provide a safe receptacle for the collection of money and (2) to provide a means for counting passengers and recording other operating statistics. The receptacle can range in sophistication from a simple box to an elaborate registering farebox that can be emptied only with a special vacuum hose. (One Dial-A-Ride operator we know used plastic refrigerator containers for fare collection until his regular fareboxes could be installed. That is not a recommended procedure, however.) Two manufacturers in the U.S. make registering fareboxes that record the amount of money as it is deposited in the box. This feature helps discourage pilferage or "skimming" by the personnel who handle the money. The KCATA uses and advanced system of this type.

When the fare collection equipment does not provide a direct count of passengers, the system manager can have drivers do the counting with mechanical counters or on written logs, or the passenger count can be estimated from revenue. It is difficult, however, to estimate ridership accurately from revenue in zoned systems or in systems in which senior citizens or students pay reduced rates. Some operators follow a one rider-one coin policy, in which special classes of riders like senior citizens must purchase tokens in order to take advantage of reduced fares. Separate counts of the different types of tokens and cash give fairly accurate counts of the various types of riders. The most sophisticated fare collection systems can record data on bus mileage, fuel consumption, and oil, coolant, and torque fluid levels in addition to revenue and passenger counts.

We strongly recommend an exact fare policy, preferably with provision for change-making with system scrip. Its acceptance is high for conventional transit, and it has simplified operations and effectively reduced robberies.

Taxi meters are not fare collection devices, but serve to compute trip-specific fares which are then collected by some other means, usually by the driver. Several advanced electronic meters are now available which allow a wide variety of fares for shared-ride or Dial-A-Ride operation. Such advanced meters combined with secure transit-type fareboxes have highly interesting potential for Dial-A-Ride use, but are quite expensive. Their performance is similar to some forms of flexible automated fare collection for buses which are under development.

For short-term Dial-A-Ride implementation, we recommend the simpler types of secure transit-type locking fareboxes. They are designed so that drivers can inspect the fare paid and then drop it into a vault. The vault mechanism automaticaly locks as it is removed, so that cleaning and servicing personnel can remove vaults without access to cash. The vaults are then later unlocked, emptied, and the revenues counted. Two vaults are required per vehicle, plus a few spares.

The revenue processing function must be carefully designed for security, but also should not take excessive quantities of personnel time. While it is conventional wisdom to remove vaults and count revenues daily, current fareboxes and vaults are sufficiently sturdy that it is not necessary. The daily revenue per Dial-A-Ride vehicle is typically quite small. If accurate passenger counts are maintained by other means and if vehicles are securely stored inside, revenue processing need occur only once a week or so. One Michigan system has done this with no problems for two years in a high-crime area.

Sorting and counting revenues before deposit is recommended, by bonded personnel under secure conditions. Simple sorting and counting devices are available at relatively low cost and pay for themselves quickly in time savings.

Alternatives to Cash Fares*

A significant minority of system passengers can be expected to prefer tickets or other forms of prepayment over cash fares. Types of prepayment include: (1) those

*An exhaustive national study of this subject by the Huron River Group is available in the MARC library.

which allow the purchaser a fixed number of rides, usually over an unlimited time period (tickets, tokens, punch cards); and (2) those which are valid for an unlimited number of rides over a fixed time period (passes, permits). Two major advantages of prepayment are that it can provide a means of effectively giving change in an exact-fare system and that it provides a mechanism by which social service agencies can purchase transportation for their clients via a Dial-A-Ride system.

In most systems two or three basic prepayment options will cover the spectrum of needs if the plans are properly priced relative to one another. The number of possible combinations is endless, and no one combination can be recommended for general applicability. General guidelines for establishing a balanced set of prepayment plans are:

- A relatively low-priced, short duration option should be made available particularly to meet the needs of low-income riders, for whom a large purchase price would be a deterrent. (A day pass, tickets, or a 10-ride punch card would be good choices).
- Much recent interest has concentrated on monthly passes as a marketing tool. Use of weekly and monthly passes is limited to frequent riders, typically commuters. If it is desired to include passes in a set of prepayment plans that everyone can use practically, passes should be complemented by a multiple-trip format like a punch card. A non-expiring punch card <u>by itself</u>, however, can serve <u>both</u> frequent and infrequent riders.
- Discounts of no more than 20 percent on punch cards or other multiple-trip formats are sufficient to attract a significant percentage of passengers to these forms, given an adequate distribution system.