RURAL PUBLIC TRANSPORTATION DEVELOPMENT OF SPECIFICATIONS FOR 16 - 24 PASSENGER BUSES

by

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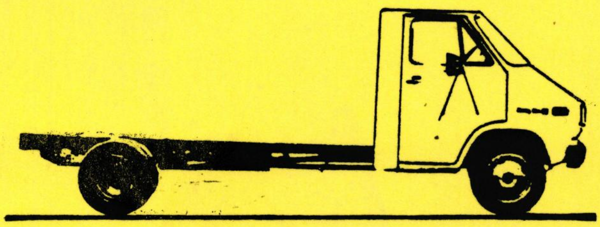

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16. Abstract

The report outlines the process of developing small transit bus specifications for the state of Arkansas and charts the road for future updating of the same. Review of the current state of the bus industry, state of the art in small bus design, relevant future technology, current field performance in the state of Arkansas, as well as, available specifications by other states was used as the basis for the development and justifications of the specifications. The same process may be repeated periodically to update the specifications.

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METRIC CONVERSION TABLE

SYMBOL	KNOWN UNIT	MULTIPLY BY	TO FIND	SYMBOL
		LENGTH		
in	inches	2.54	centimeters	cm
ft	feet	30.48	centimeters	cm
ft	feet	0.30	meters	m
yd	yards	0.91	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	6.45	square cm	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.84	square meters	m^2
mi^2	square miles	2.59	sq. kilometers	km^2
	acres	0.40	hectares	ha
	acres	4046.87	square meters	m^2
		VOLUME		
in^3	cubic inches	16.39	cubic cm	cm^3, cc
ft^3	cubic feet	0.03	cubic meters	m^3
ft^3	cubic feet	28317.0	cubic cm	cm^3, cc
yd^3	cubic yards	0.76	cubic meters	m^3
gal	gallon (U.S.)	3.79	liter(1000 cc)	l
qt	quart (U.S.)	0.95	liter	l
oz	ounce fluid)	29.57	cubic cm	cm^3, cc
		WEIGHT		
lb	pound(avoirdupois)	0.45	kilogram	kg
lb	" "	453.59	grams	g
oz	ounces(")	28.35	grams	g
	short ton(2000 lb)	0.91	tonnes(1000kg)	t
		FORCE, PRESSURE		
lbf	pounds-force	4.45	newtons	N
psi, lbf/in^2	pound-force/square inch	6.89	kilopascals	kPa
	foot of water(39.2 ^oF)	2.99	"	kPa
	inch of mercury(32 ^oF)	3.39	"	kPa
		ANGLE		
^{o}	degrees	0.017	radians	rad
'	minutes	2.91×10^{-4}	radians	rad
"	seconds	4.85×10^{-6}	radians	rad
		TEMPERATURE		
^oF	degrees Fahrenheit	$t^oC = (t^oF - 32)/1.8$	degrees Celcius	^oC
^oC	degrees Celcius	ADD 273.15	degrees Kelvin	^oK

VOLUME I

DEVELOPMENT OF SMALL TRANSIT BUS SPECIFICATIONS FOR THE STATE OF ARKANSAS

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SUMMARY AND IMPLEMENTATION STATEMENT

This publication describes and documents the methodology and process used in the development of small transit bus specifications for the state of Arkansas. The report provides a basic review of the literature on the small bus industry and the role of small buses in transit. The specification development process involves review of the current state of the art in small bus technology, and current specifications adopted by other states. It covers, also, the survey and evaluation of performance and maintenance problems of small transit buses in Arkansas, which provides the foundation for the development of the specifications to correct such problems. Small bus specifications are covered in a separate publication.

The information provided in this report may be used as a means to document the specification development process and to provide the background for establishing such specifications. Information provided on the small transit bus performance in Arkansas may be up-dated and monitored to detect improvement trends due to the new specifications.

Developments in materials and component technology lend a dynamic aspect to bus specifications. Specifications need to be reviewed and updated regularly. The model outlined in this report and used in the development of current specifications can be used in the up-dating process.

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FORWARD

The urban mass transportation act of 1964 ushered in a new era for the revival of public mass transportation in the USA. The following two decades brought about a stream of changes and adjustments to help improve various aspects of public transportation and to accommodate the desire to improve the urban environment, satisfy the needs of the elderly and handicapped and assume a great financial role in the operation of transit systems.

The support program for the transportation of the elderly and handicapped, referred to as the 16(b)(2), was initiated in 1974. Funding became available to private non-profit organizations on an 80/20 federal/local match, and may be used to acquire vehicles and support equipment. The program funds are allocated to each state which in turn solicits applications from eligible recipients who can only be private non-profit organizations. The applicant must be able to show sufficient evidence of ability to provide administrative and financial capabilities to sustain the program, provide the local funding share of 20% and assume the responsibility to provide transportation for the elderly and the handicapped.

Section 18 of the Urban Mass Transportation Act of 1964, as amended, authorizes the Secretary of Transportation to apportion funds to the governor of each state for public transportation projects in non-urbanized areas. The funds, appropriated annually, are made available on a population-based formula and may be used for all projects included in the Section 18 statewide Program of Projects. A Program of Projects must be submitted at least annually to the UMTA Regional Administrator for approval. The Program of Projects must provide for fair and equitable distribution of funds within the state, including Indian reservations, and must provide for maximum feasible coordination with transportation services assisted by other federal sources.

Program funds may be used for planning, capital, operating and administrative assistance to state agencies, local public bodies, non-profit organizations, Indian Tribes and groups and operators of public transportation services. An amount not to exceed 15 percent of the state apportionment may be used for state administration, planning and technical assistance activities.

The goals of the Section 18 Program are:

1) to enhance the access of people in non-urbanized areas to health care, shopping, education, employment, public services and recreation;
2) to assist in the maintenance, development, improvement, and use of public transportation systems in rural and small urban areas;
3) to encourage and facilitate the most efficient use of all federal funds used to provide passenger transportation in non-urbanized areas through the coordination of programs and services; and
4) to provide for the participation of private transportation providers in non-urbanized transportation services to the maximum extent feasible.

Because of the very nature of transportation in rural and small urban areas, small buses have become a heavy favorite in place of large transit buses. Service needs of rural and small urban areas require a mix of modes ranging from fixed route, fixed schedule to on-demand service. Small buses offer a greater degree of flexibility in meeting the variety of service demands. In addition, they do not require professional bus drivers, nor would they necessarily require specialized maintenance facilities.

While large transit bus design evolved over decades of improvement and redesign based on feedback concerning operating performance in various urban environments, small buses have had a relatively short history of operation in the transit field. Furthermore, small transit buses evolved primarily from small school buses and represent, in general, a small portion of the total school bus market. At the same time they present school bus manufacturers with a new set of requirements. Most of these manufacturers are not totally prepared to handle basic design and tooling changes to accommodate major departure from current bus design.

Some of the persistent problems in small bus design result from the fact that most such buses are constructed in, at least, two distinctive steps by two different manufacturers. The first builds the general purpose chassis which are used, among other applications, for recreational vehicles and delivery trucks. The second is responsible for constructing the bus body, equipping the interior and installing the necessary accessories. This complicates the process of bringing about necessary design changes to adapt the bus chassis and body to the more demanding service encountered in public transportation. In addition, the two tier process encountered in bus construction has simplified bus manufacturing and provided an open invitation to small manufacturers to enter the small bus market. This resulted in a variety of approaches to the final construction process and in a mix of quality for the finished product. Accordingly, small bus manufacturing ranges from raising the roof and modifying the interior seating to providing major modification of the chassis and using novel technology in body construction.

While the variety of construction methods and quality commonly offer a broader market choice to the buyer, they tend to play an adverse role under the lowest bid purchase process used by procuring agencies. In the absence of adequate specifications, it is difficult to disqualify low quality equipment, and while the buyer can achieve some initial cost saving by purchasing low price vehicles, he is more likely to be faced with future problems, greater maintenance and higher overall cost in the long run.

The relatively short history of small bus acquisition and use for public transportation is full of examples of short comings in design and performance. It is also studded with various attempts at the national and the state levels to bring this problem under control. Efforts at the national level focused on means to incorporate advanced state of the art technology in bus design and on the sponsorship of various demonstration projects to test and report equipment performance. Efforts involved also studies aimed at the development of guidelines to help small buyers select the most economical bus type based on the expected life cycle cost. Efforts at the state level focused primarily on the development of small bus specifications to improve bus quality and to exclude trouble prone vehicles and equipment.

The development of small bus specifications for the state of Arkansas is another effort to improve small bus quality and acquisition process. The state of Arkansas faced some of the same problems most other states had in procuring and using small transit buses. Breakdowns, extended repairs, downtown, and inadequate performance have been repeated at many public transit agencies in Arkansas as they did elsewhere. Meanwhile, the Public Transportation Unit of the Arkansas Highway and Transportation Department has worked diligently with various bus operators of sections 16(b)(2) and 18 to alleviate some of these problems, particularly when the equipment was still under warranty, or when unexpected breakdown for which the manufacturer may not be legally, but is morally, responsible occurred.

SMALL TRANSIT BUS: VIRTUES AND SHORTCOMINGS

While it is easy to identify and classify large transit buses, it is often difficult to do the same for small buses. Large transit buses evolved over years of improvement and redesign to a relatively mature and stable product. Improvement was based upon operating feedback and experience in the urban transit environment. Major bus components including engine, drive train, suspension and brakes have been designed to endure the severe service encountered in the stop and go driving associated with urban travel. The large transit bus industry has also reached a greater degree of maturity, and the market is presently dominated by a handful of U.S. and foreign manufacturers. The "New look" model introduced as early as the late forties has brought the industry closer towards standardization. Under the skin, large transit buses are fairly equipment-standardized vehicles which share some of the major components and optional equipment.

By contrast small transit buses are still in the developing stage, and although they have been around for sometime, it was not till recently that they were used widely in public transportation. Small buses have traditionally been used as school buses, and the basic chassis is also used in the construction of step vans and delivery trucks. The emergence of section 16(b)(2), transportation for the elderly and handicapped, and section 18 Rural Public Transportation and the availability of grant money to support both programs cause the demand for small transit buses to accelerate. This is expected to broaden the base of use of small transit buses and to provide stable demand to help the bus development process.

It is difficult to find a widely accepted definition of small transit buses (35). A broad classification would place them between modified vans and large transit buses. They may be further classified as body on van chassis, body on modified van chassis, body on medium truck chassis (used with school bus), body on modified medium truck chassis and purpose-built. Although lengthening the chassis is one of the common modifications, the previous reference to modification is meant to be more extensive with the purpose of strengthening the chassis and incorporating heavy duty components into it. A classification which emphasizes the type and general features of the bus is shown in Table 1 which is adopted from reference (35). Bus length provides another distinguishing feature of small buses. While 40 feet is considered to be the length of a large transit bus, 22 feet and below appear to include most of the vans and converted vans. For the purpose of this study, small transit buses are considered to be bounded by the two previous classes. Twenty-six and thirty ft. buses fall in the small buss category which also includes most of the purpose-built and small forward control chassis vehicles. Twenty-six ft. bus, which is more maneuverable in comparison to the thirty foot bus, seems to hold the marketing edge in certain applications. Some manufacturers have sought to produce both the 26 ft. and the 30 ft. buses to satisfy a broader interest in the market place.

The main virtue of small transit buses is their size since they have smaller wheel base, body size and turning radius (turning radius is considered to be roughly equal to the length of the bus). They can therefore negotiate narrow streets and would be more suitable for providing paratransit and door to door service. Size also allows more flexibility in meeting a variety of special demands that are common in special transit. Small bus interior is particularly flexible and may be designed to suit the type of service offered. This may include regular and wheelchair passengers, as well as, stretcher patients. The flexibility in the interior layout of the bus in

TABLE 1 Small Bus Classes

(Adopted from: "Small Bus Manufacturing Industry," by B. J. Weiers, UMTA Office of Technical Assistance, Washington, D.C., January, 1985)

VEHICLE TYPE	CHASSIS MANUFACTURER[1]	COMPLETE BUS (Manufacturer and Model Name)[1]	
VAN STANDARD VAN	N/A	G.M. Ford Dodge	
CONVERTED VAN (Conversion would include raising the roof and providing suitable seating plan.)	General Motors Ford Dodge	Fortibus AmTran Minuteman	National Coach Escort Turtle Top Terra National Custom Van
BODY ON VAN CHASSIS	General Motors Ford Dodge	Fortibus Thomas Minotaur Wayne Chaperone Collins Omni/Bus	Bluebird Microbird AmTran Ward Minuteman El Dorado People Mover Champion Bus
BODY ON TRUCK CHASSIS (2) Forward Control Chassis Small	Wolverine Western General Motors	Coach and Equipment Flxette Bluebird Minibird	CL series Thomas Might Mite
Large	International Harvester (3)	Carpenter Cavalier Bluebird All American	AmTran Patriot
Medium Truck Chassis (conventional school bus)	General Motors Ford International Harvester	Bluebird Conventional Thomas Conventional Wayne Lifeguard	AmTran (Ward) Volunteer Carpenter Conventional
Rear Engine Bus Chassis	(3)	Bluebird All American RE Thomas Transit Liner ER	Carpenter Corsair
PURPOSE-BUILT 25'	N/A	Chance RT 50	
26' low floor	N/A	Orion II Neoplan Lit'l Bus Skillcraft	
30'	N/A	Gillig Phantom Bluebird Citibus Carpenter CBW 300	Thomas Citiliner

(1) List is not exhaustive.

(2) Driver controls are located above or in front of the front axle.

(3) Bus body builders commonly build their own chassis.

(4) N/A - not applicable.

comparison to the standard and modified vans is a result of the additional width and headroom of the bus body. This allows suitable walking aisles which provide easy access for seated and wheelchair passengers. In addition, small buses do not have the intimidating presence and do not generate the noise and diesel exhaust commonly associated with large transit buses. This makes the bus more acceptable in residential neighborhoods. Another virtue of small buses that should not be over looked is the low initial cost. While such an advantage may be more than reversed when the life cycle cost is considered, never the less, at times of tight budgets, the initial cost advantage may make the difference between establishing the service and not being able to afford it in the first place.

The shortcomings of small bus as a general purpose transit vehicle stem from two reasons; limited passenger capacity and lack of durability. The first shortcoming, while not unexpected, tends to limit the bus capacity in handling peak hour load. It also adds considerably to the operating cost based on seat-mile by distributing the driver's cost over fewer passengers. This tend to place small buses out of the competition with the large transit buses and identifies them with a special nitche in the public mass transportation market, namely, special and paratransit service where flexibility and maneuverability outweigh the need for capacity to handle passenger flow.

Perhaps one of the most serious shortcomings of small buses is their lack of durability in the public transportation environment. While small bus manufacturers have been working to achieve a more durable bus, some of the basic problems involved have not been easy to overcome. Large transit bus components were developed to meet the severe urban travel service, while small bus construction and components are of the type and quality used in large automobiles and vans. Improving chassis design and durability must be done judiciously so that balanced improvements can be achieved, otherwise emphasis on one component may aggravate the weakness of others. This would inherently place a limit on the degree of achievable improvement for the whole system. Improving ride quality, for example, may require the use of a different suspension system which would in turn require major frame modification. It is also unescapable that additional weight will result which would cause deterioration of the fuel efficiency and handling qualities of the bus. In addition, such modifications would not be cheap, since it is akin to design customization. The cost of extensive chassis modification is likely to be high unless it is performed on a large production scale, which seems unlikely because of the industry fragmentation.

The purpose-built small bus offers a glimmer of hope for overcoming the durability problem. Building the bus from the ground up allows the manufacturer the opportunity to build a bus which is more suitable for transit service. Several manufacturers have attempted to develop durable, purpose-built designs which would have very low floors, making them easier to enter for the elderly and, in some cases, wheelchair-accessible by means of simple ramps rather than complex and expensive lifts. This approach is still subject to some limitations since, even for purpose bus builders, the choice of major components is limited and tend to reduce their options. If they opt, for example, for some of the large bus heavy duty components, they will soon find themselves building a large bus in the skin of a small one. This would not be desirable from the stand point of vehicle weight, fuel economy, ease of maintenance and cost.

The limited availability of domestic componentry and chassis has led some bus manufacturers to explore using foreign-built chassis or components.

IVECO, a subsidiary of the Italian company Fiat, has actively promoted the use of its Z-van chassis as a substitute for U.S. van cutaway and small forward control (steering and driver controls are placed ahead of the front axle) chassis. Isuzu, a Japanese automobile and truck builder, has been trying to market bus chassis in the U.S. as well. Several bus manufacturers have been seriously considered using Isuzu 26-ft forward control chassis or Isuzu 31-ft rear engine chassis as a basis for their buses. Some have built prototypes, although none have announced production at this time. This road is not without its own pitfalls, and it is likely to take some time before the basic problems in this approach are all sorted out. It is, however a feasible avenue in light of the desperate search for a more durable small bus.

SMALL TRANSIT BUS INDUSTRY*

The small transit bus industry represents a conglomeration of small manufacturers and divisions of large companies who are active in one aspect or another of the production of small buses. At the top of the list, both from a commitment and vehicle durability standpoint, comes the transit purpose bus builders, who construct the bus from the ground up explicitly for the purpose of serving public transportation. The chassis producers who include G.M. and Ford are engaged in producing chassis for small buses as well as a variety of other applications. The second tier of manufacturing which involves building the bus body over the chassis is performed by a number of school bus and small bus manufacturers. These include Wayne, AmTran (Ward), Carpenter and several others who produce and market small buses for adult transportation. Small bus manufacturers include also limited entries from companies which produce step van and delivery trucks, as well as, companies in the recreational vehicle industry.

School bus manufacturers demonstrated serious interest and a higher degree of commitment to the U.S. transit market during the seventies because of the decline in the school bus market. The availability of federal funding for small transit buses helped, in the meantime, to fuel the demand and industry's interest in building small buses. This has been evidenced by the introduction of new buses both of the purpose-built and the body on chassis types. Gillig, after an unsuccessful venture with a small Neoplan bus design, introduced its heavy-duty Phantom transit bus in 1981. The Phantom

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*Adapted from reference. (35)

was produced in 30-, 35-, and 40-foot versions. Gillig used this model in competition with large transit buses produced by G.M., Flexible and Neoplan. Bluebird, which built its own chassis, entered the small transit bus market with a 30-foot rear engine bus in 1976. Thomas-built began building its own rear engine chassis in 1977. Carpenter, after introducing a 30-foot transit bus on a Gillig chassis in 1982, began building its own chassis in 1983. Several school bus manufacturers also introduced small forward control chassis (stepvan) and van cutaway-based small buses for adults. The introduction of these vehicles, in some instances, paralleled the introduction of small school buses which used the same chassis. The Thomas-built Mighty Mite, originally introduced on a short truck chassis in 1970 was later re-introduced on a G.M. small forward control chassis (the P-30 stepvan chassis), the Am-Tran Patriot and Wayne Transette are other examples.

Manufacturers of stepvans and small delivery trucks are among those with special capability to produce small transit buses. Stepvans or multi-stop trucks were designed with low, unobstructed floors for easier driver and cargo accessibility. The manufacturers used a small forward control chassis to maximize the available cargo space in a small maneuverable vehicle. For the most part, major truck manufacturers (G.M., I.H., and later, Ford) produced the small forward control chassis and sold them to body manufacturers (Metropolitan, Union Truck Body, Boyertown, Grumman Olson, and others) who completed the vehicle production.

The small forward control chassis has several characteristics which make it appealing for transit bus use. Unlike most truck chassis, it is used on city streets, at slow speeds, and for stop and go duty cycle. Moreover, its forward control, relatively low-floor design makes it suitable for passenger capacity and accessibility.

The Flxette, one of the most popular buses to use a small forward control chassis, was introduced in 1965, and is still in production today having survived several changes in the ownership of the firm which makes it. Grumman Olson, which specializes in producing lightweight aluminum step vans, introduced an aluminum bus seating 17 to 24 passengers in 1974, thus emphasizing the fuel economy of its light weight. The Olson bus remained in production for several years. Boyertown, another step van body producer, has built small buses using forward control chassis for several years. School bus manufacturers have also built buses using the small forward control chassis.

The oil crisis of mid-seventies had direct impact on delivery truck sales. The unavailability of an appropriate diesel engine for this size vehicle further handicapped sales in an era of increased fuel prices. International Harvester ended production of its chassis and the International Metro Multistop series stepvan in 1975. Ford ended the production of its P-series forward control chassis in 1980, leaving only General Motors to produce a small forward control chassis.

Ford, since dropping its P-series, has re-entered the competition with G.M. by producing a stripped van chassis (i.e., one without any cowl or hood) with a relatively high gross weight vehicle rating. Several bus producers use this stripped van chassis to produce small forward control buses.

Motor home manufacturers represent another source for the production of small transit buses. Motor homes are either built on a light truck chassis, on a chassis produced by a chassis manufacturer, or on a special purpose chassis built by the motor home manufacturer. While not totally suitable for the severe service of a transit bus, the motor home chassis still offered the advantage of a low floor design which makes it easily accessible. The motor home industry went through a period of rapid growth from the early to mid seventies until the increase in fuel prices precipitated considerable drop in sales. The rapid change in energy cost developed a need for rapid adjustment and retrenchment in the industry which did not allow a transition to the transit field. This caused companies to abandon plans to enter the transit market and concentrate on realigning current products and operations. Despite this trauma at least one mobile home manufacturer has been able to produce a small bus on a van chassis which indicates that this group of manufacturers are likely to recover and play a future role in the small bus market.

Purpose-built small buses are not totally new although their past history is checkered with a flux of new product introductions and withdrawals. In 1974, Flxible introduced a 30-foot version of its New Look bus. Flxible decided to withdraw this bus, which was similar to GM's 30-foot model, in 1976. Following Flxible's departure from the market, several other firms introduced purpose-built small buses. In 1976, Bluebird introduced the City-bird, a 30-foot, purpose-built transit bus. The Chance Minibus RT-50, a 22-foot purpose-built bus was introduced in the same year. In 1977, TMC, a subsidiary of Greyhound Bus, bought the rights to the design of the Orion, a 30-foot bus built in Canada by Ontario Bus Industries.

The purpose-built bus sector of the small bus manufacturing industry has continued to expand since 1977. TMC stopped production in 1982, selling its license back to Ontario Bus Industries. Ontario Bus subsequently invested in a U.S. production plant and continued manufacturing the Orion. As previously mentioned, Gillig, Thomas-built and Carpenter have all introduced 30-foot purpose-built buses. Carpenter reportedly invested a $7.5 million in a new plant to produce its transit bus. Neoplan, a manufacturer of standard and articulated buses, introduced a 26-foot, low-floor, purpose-built bus in 1983. Bus Industries of America the U.S. arm of Ontario Bus Industries, began marketing the Orion II, also a 26-foot, low floor bus.

NATIONAL EFFORT TO IMPROVE SMALL BUS ACQUISITION

The interest in small bus performance,durability, maintenance and life cycle cost became widely spread when various states shared the same poor experience with small transit buses. The federal government became also concerned because of federal participation in support of bus acquisition. As far as can be determined, initial efforts to address this problem took on the form of bringing together a group of individuals who share interest in the small bus acquisition area for the exchange of information, ideas and solutions to the problem. Such exchange has been extremely productive as evidenced by review of the proceedings of such workshops (6, 14, 31). It was obvious, however, that while some states have sufficient experience with small bus performance problems, and have development tentative sets of specifications, no attempt was made to assemble a national set of specifications. Nor there were signs of the emergence of agreed upon means to motivate small bus manufacturers to adhere to certain standards. This was perhaps a reaction to the unsuccessful attempt to do the same with the large transit bus manufacturers. The fragmented nature, and lack of leadership in the small transit bus industry may have also negated any efforts to bring about a national standard in this area. This, however did not stop the states from coming up with their own specifications which were not necessarily homogeneous. The workshop was useful in that respect, since it provided an open exchange between users to share their experience in this area.

Attempts are also being made under UMTA's New Bus Equipment Introduction (NBEI) program to test new design technology in transit vehicles and the small buses are receiving their share of attention. Central Ohio Transit Authority (COTA) and Michigan Department of Transportation were provided with grant money to purchase and evaluate up to ten small buses. The program is expected to yield valuable data on the accessibility, durability, maintenance and life cycle costs for these buses.

Other new technological innovations under test include; Twenty small buses with turbo-charged diesel engines and computer controlled fuel mixture system by the District of Columbia Department of Transportation; five small buses with low floor, disc brakes, and heavy duty diesel engines by the Central New York Regional Transportation Authority; six small buses with wheel chair ramps, lower floors and diesel engines by the Lincolin Transportation system in Lincolin, Nebraska; and two small buses with accessible features and capability of climbing 10% grade at 35 m.p.h. by South Coast Area Transit in Oxnard, California.

The process of purchasing buses equipped with special feature for testing purposes through the regular bid process has proved to be a delicate one. The Michigan DOT has been successful in awarding contracts for the type of bus required for the test evaluation program. This was accomplished through a two stage bidding process (4). A foreign manufacturer was able to meet the requirements, as well as, submit the lowest bid. Additional innovative features found in the buses acquired by the Michigan DOT and which will also be subject to evaluation include: (a) front wheel drive, (b) modular power train construction, which includes engine, transmission, wheel drive assembly, suspension and cooling system, that rolls out for service, (c) stainless steel welded unit body structure, (d) accessories (cooling fan, alternator, air conditioning compressor) that are hydraulically driven which isolates them from speed variations of the engine, (e) alternative window design for low floor,

(f) oversize wheels and brake system, (g) low floor with kneeling capability, and (h) front door located directly across from the driver.

At a more global level, a major study sponsored by UMTA under the National Cooperative Transit Research & Development Program (NCTRP) to develop a manual for improved purchasing, use and maintenance of small transit buses has been completed. The study sought to establish a comprehensive data base on small transit buses which would include actual performance data, incidents if breakdown and maintenance, as well as, complete maintenance cost data. At the same time the data includes a complete account of factors contributing to the maintenance cost such as the type of bus, severity of service and the operating environment. The study attempted to cover a representative sample of equipment, type of service and operating environments. Data has been collected from 27 transit agencies from various parts of the country. Nineteen of the 27 agencies have provided data sufficiently complete to warrant entering into the large computer data base. The (19) agencies represent a total of 233 buses, almost eight thousand maintenance events, 2.6 million bus-miles, and 1200 bus months of operation.

The study provided means, in the form of a flow chart, to analyze and choose the appropriate type of bus for the application on hand. Bus types are classified mainly as van, body on van chassis, body on truck chassis and purpose-built. Life cycle cost and intangible factors are proposed as the basis for making the comparison between the different types of buses. One of the important findings of the study was the determination that the type of bus, severity of service and current mileage have significant effect on the maintenance cost. The relationship was calibrated in the form of a regression model which can be used to predict the maintenance cost. The study, therefore, provides a basic choice model to help transit agencies select the appropriate and most economical type of bus. The model was calibrated to reflect the prevailing conditions for all parts of the U.S. This model has the advantage of simplifying the process of initial bus selection and require the bus buyer to provide only basic data for that purpose. On the other hand the model is limited to the initial choice of bus type.

The previous study did address the area of specifications in a general way, and the collected data were not used to draw up conclusions with regard to equipment performance. Such a step would have been of benefit to buyers and bus manufacturers alike. Bus manufacturers, like most other manufacturers, could benefit from feedback regarding performance and maintenance requirements of their equipment.

STATE EFFORTS TO IMPROVE SMALL BUS ACQUISITION

Efforts at the state level have focused primarily on the development of small bus specifications and on streamlining the acquisition process. The intention is to utilize bus specifications, vender bidding and the bid evaluation process as an effective tool to filter out trouble prone equipment and less qualified methods of construction. In addition, the states participated in a number of government supported demonstration projects to test design concepts and novel manufacturing methods. The states provided the appropriate setting for the tests, collected the necessary data and provided means to disseminate the results so that other states could benefit from the demonstration projects.

Perhaps the greatest state contribution, in the absence of industry wide standards, has been the development of small bus specifications, and in succeeding to bring the whole issue of small transit bus performance to the forefront of the industry-transit operator debate. The specification coverage, depth and the degree of emphasis on specific components of the bus did, however, vary from state to state. While some states, for example, approached specifications in a fairly general manner, others focused more heavily on details of materials and methods of construction. In general, state specifications provided considerable coverage of the bus, its components and various options. The level of detail encumbered in some of the specifications, particularly with regard to the method of bus construction, could only be justified on the basis of the lack of industry wide standards. It is also worth noting that the state specifications showed a wide range of variation with regard to the specific components and materials. Part of this variation can be justified on the basis of the expected variation in operating environment and the type of service to which the bus would be subjected to in various states. On the other hand, some of the variations particularly those covering less significant items (plywood material for steel floor lining, steel used for stepwell and stairs,...) are likely to perpetuate the status-quo in the industry, which treats each bus as a custom built product. This inhibits product standardization and minimizes the chances of reaping the economic benefits of the production scale.

The value of performance specifications versus design specifications was also addressed. While design specifications assure design and manufacturing quality, it does not guarantee bus performance. Performance specifications, on the other hand, allows the designer a greater degree of flexibility, while at the same time they are difficult to verify without the use of standard testing methods and instrumentation.

The adoption of a two stage bid process has become well accepted as means to moderate the impact of detailing specifications and procedures in the acquisition process. The first state of the bid process (pre-bid conference) provides an opportunity for an open exchange between the buyer and potential bidders regarding clarification of specifications, waving of requirements, approval of equals, as well as, feedback and adjustment regarding bid conditions, warranty, and data required by the buyer.

Various approaches were also adopted to insure vehicle performance after delivery. These ranged from requiring performance bonds, to the purchase of extended warranties which go beyond the standard warranty. Life cycle cost has also been used in this respect by requiring the vendor to submit a projected maintenance cost for major components of the bus, as well as, a certified fuel consumption rate. Although the previous approach seems to place a degree of certainty in the bus selection process, there is a concern that this would place an undue burden on the bidders and may result in eliminating some of the vendors and hence limiting the competition.

The process of assuring that the bus delivered by the vendor meets the required specifications also received its share of attention. This ranged from arranging visits to the vendor facility during bus construction to assure that bus quality and methods of manufacturing are according to specifications, to the application of a complete inspection procedure on the finished bus to assure an acceptable finished quality.

While the technical aspects of the procurement process have been subjected to various adjustments, the administrative side of the process has also been the subject of some modifications. The issue here was centralized procurement by the state versus direct procurement by individual agencies based upon specifications and guidelines provided by the state. Both approaches are used, however, preference seem to be in favor of the centralized system whereby a central agency handles the purchasing with a strong input from the vehicle users.

APPROACH AND CONSIDERATIONS IN THE DEVELOPMENT OF SMALL BUS SPECIFICATIONS FOR THE STATE OF ARKANSAS

Adequate bus specifications is the cornerstone of the bus acquisition process. The process consists of a number of steps leading to the bus purchase and delivery. The steps are summarized in the following:

1. Projection of demand for service
2. Fleet management requiring review of current fleet assignment to reduce the operating and maintenance cost.
3. Establish alternatives of vehicle type, and capacity based upon projected demand and system operation considerations.
4. Evaluation and determination of vehicle type and capacity based upon the projected life cycle cost.
5. Detailed vehicle specifications.
6. Bidding process and bus purchase.
7. Delivery and inspection.

While the focus of the current project is on the bus specifications, it is important, however, that other phases of the bus acquisition process be recognized and applied properly. Bus acquisition process is explained in the following:

1. Projection of Demand for Service

Rural transit, section (18), involves primarily fixed route, fixed and variable schedule. Analysis of demand in this situation involves projection of travel demand through public surveys or the use of adjusted historical data; mode choice adjustment and travel assignment. Methodology for the projection of travel demand for large urban areas are well established. Simple approximate models are available for rural and small urban areas (3).

Demand for section 16(b)(2) services depends upon the geographical and social setting of the service area. The number of senior citizens in the community the nature of their local activities, and the special needs of handicapped persons must all be taken into account in projecting the demand for service. This would require survey of the special clientele who would use the service and the use of historical ratios to project the demand for service (34).

2. <u>Fleet Management</u>

Fleet management involves review of current fleet condition as reflected in past maintenance incidents, cost and operators opinion. Projection of maintenance cost under various types of service could be used as a guide to reassign vehicles in such a manner so as to minimize the maintenance cost and improve service reliability. In general, the approach is to assign vehicles with greater accumulated mileage and/or higher expected incidents of maintenance and cost to routes requiring fewer miles per year and light duty service.

Vehicle maintenance cost is difficult to project based upon historical trend alone. Vehicle maintenance cost was found to follow the repair-repair--replacement cycle for various systems, subsystems and components of the vehicle. Under circumstances when preventive maintenance is not fully adopted, maintenance incidents and cost associated with a certain system on the bus increases gradually towards the end of the system's useful life. This is followed by a sharp increase when the system is replaced. The cost then drops and pursues a moderate annual increase, until it reaches the end of the new system's useful life. The long term maintenance cost could, however, be approximated as a linear function of the vehicle miles (3).

It is also difficult to predict the maintenance cost of new vehicles, however, historical data based upon a large sample size could be used as a reasonable predictor of the maintenance cost.

3. <u>Establish Alternatives of Vehicle Type, and Capacity</u>

Projected service needs may be satisfied by the use of various arrangements of vehicle type and capacities. Available vehicle types include van and modified van, body on van chassis, and body on a truck chassis. Each of these vehicles has a different initial cost, operating and maintenance cost structure. In addition each has different physical specifications, operating characteristics and available options to meet the special needs of the service.

4. <u>Evaluation and Determination of Vehicle Type and Capacity</u>

The alternatives established in (3) are evaluated to determine the most desirable choice. The evaluation is based upon the life cycle cost and on other intangible factors. Life cycle cost includes the initial cost of the vehicles, the cost of maintenance, fuel and operators. These costs are accumulated and redistributed over the useful life of the bus. Data regarding the basic cost structure for the various types of vehicles has been developed based on a large survey sample (3). Local cost factors are incorporated in the model to adjust the cost to the local conditions. Intangible factors, some of them are important, include the need to maintain uniformity in vehicles of the fleet, the availability of desired options on the vehicle and the availability of local service.

5. <u>Detailed Vehicle Specifications</u>

Detailed vehicle specifications are important to assure that the vehicles provided are built to the correct engineering standards and are capable of withstanding the transit service demands. The history of the industry and the availability of light duty equipment which is not suitable for the transit service makes it important to maintain adequate and current vehicle standards.

The standards serve the main purpose of providing guidance to the bus manufacturer in the design and construction of the transit vehicle. They are particularly aimed at the vehicle systems, subsystems and components which have been a source performance deficiency in the past.

6. Bidding Process and Bus Purchase

A two stage bidding process or at the least a pre-bid conference has been recommended for the small bus acquisition process. This is used as means to communicate bus specifications to the prospective bidders, answer any questions and entertain feedback. The need for this step has been emphasized because of the detailed nature of bus specifications and the need to assure that they have been properly interpreted by the bidders. This will allow more companies to enter the bidding process.

&. Delivery and Inspection

Pre-delivery inspection is a commonly accepted practice in the purchase of major pieces of equipment. Inspection is performed at the plant where the equipment is produced. This has the advantage of correcting any quality defects at the plant. The same practice is used in the purchase of transit buses. Manufacturing inspection, where the manufacturing process and facilities are inspected, has also been reported. This allows the inspection team to verify that buses are manufactured according to specifications and that appropriate quality control measures are being followed in bus construction. Receiving inspection is still another approach to assure that the bus meets the specifications. This is best performed when planned around a formal inspection procedure. It identifies any quality defects and have them corrected under warranty clause.

SMALL BUS SPECIFICATIONS DEVELOPMENT PROCESS

Small bus specifications have been developed by a number of other states, some of them have made pioneering effort in this area. State specifications tend, however, to reflect the operating environment and the type of problems encountered in the particular state where the specification is used, this is also true of the state of Arkansas. On the other hand, it is important that such specifications have a cumulative effect and that late comers benefit from the hind-side advantage in developing their own specifications.

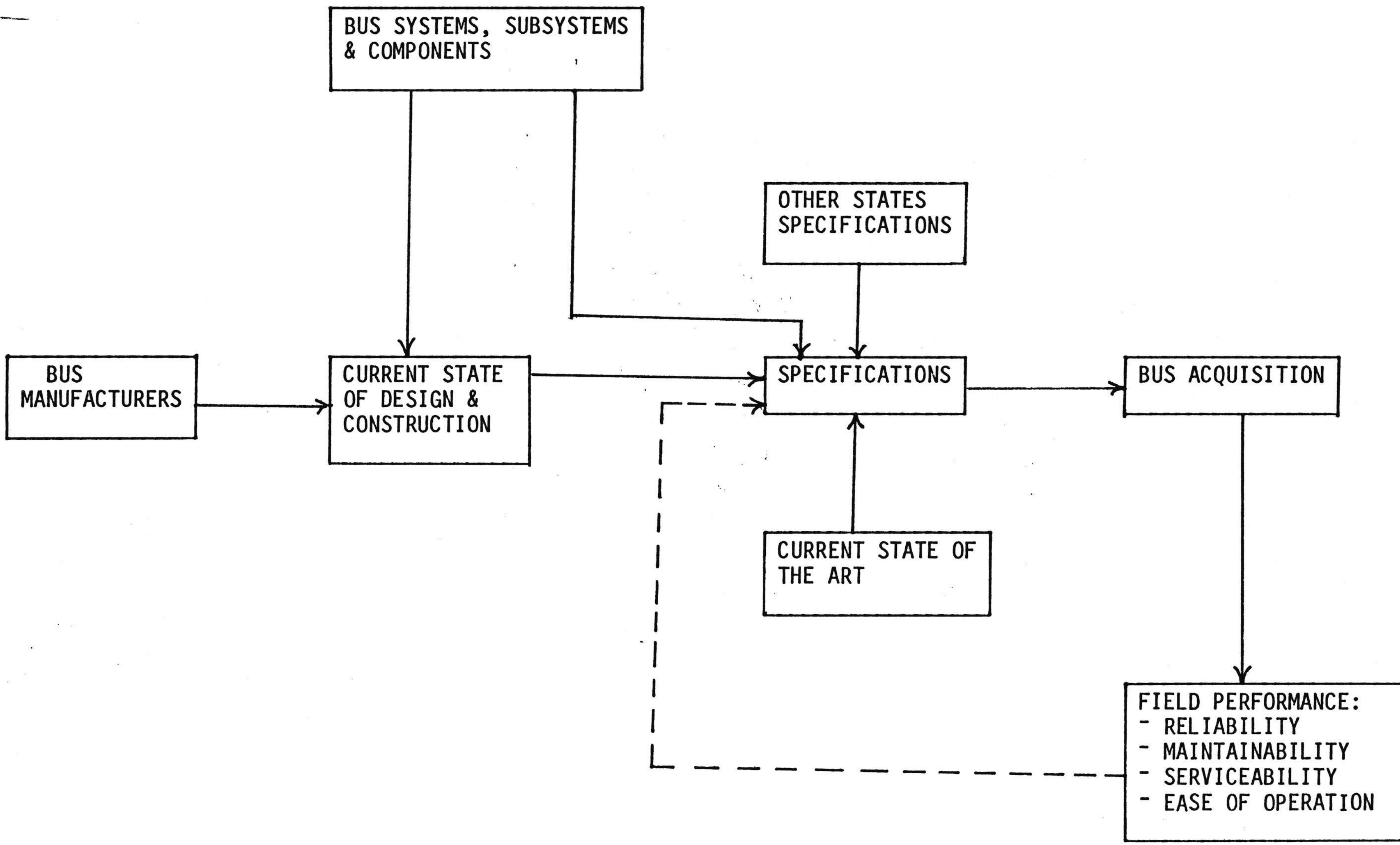
The development of small bus specifications is viewed as a continuous process aimed at achieving a reliable, easy to maintain and low operating cost small bus. Specifications are not envisioned as means to provide a blueprint for the small bus industry to follow. They are primarily aimed at areas where current and potential problems exist. In this sense, they are intended as a safeguard against the degraded performance of small buses in the transit field. The obvious ramification of this approach is in the variation of the degree of specification coverage. This degree seems to vary according to the amount of reported problems with the specific bus system, subsystem or component. Those showing higher rates of problems have received a greater share of the attention.

The specifications development process is outlined in Figure 1. The process is depicted as closed loop in which field performance provides an important and continuous feedback which is used among other inputs in the modification and updating of specifications. The basic elements of the small bus specification development process are described in the following:

Bus Systems, Subsystems and Components

Small bus specifications are developed in a framework representing the

FIGURE 1: Small Bus Specifications Development Process



make-up of the bus. The framework is hierical and reflects the method of bus construction, component and accessory selection. This framework was used throughout the project for evaluating system reliability, maintainability and potential for improvement, as well as, in the development of specifications. The basic framework for bus system breakdown is shown in Table 2. This same structure may also be used in the development of a data base to be used in an ongoing process for small bus improvement and specification updating.

Bus Manufacturers

Bus specifications could not be achieved in isolation of the state of development of the bus manufacturing industries. The degree of capitalization, technical depth and willingness of management to undertake risky product development indicate the extent to which the industry would be able to successfully adopt new technology and improve the current one. In addition, bus manufacturers provide the starting point for determining the current state of design and construction of small buses. The history of product and company evolution is important in establishing relationship between current field experience and bus design, and in projecting future developments in the field.

Current State of Design and Construction

Current state of bus design and construction has been established through the collection of specifications of a wide range of small buses and modified vans. Specifications have been closely reviewed and further contact with bus manufacturers was necessary to obtain additional details regarding the construction specifications and the type and make of available options. It was clear from this exercise that a certain degree of customizing is available throughout the industry. This has led bus manufacturers in many cases to leaving the specifications deliberately vague to provide room for tailoring

TABLE 2: Bus System Breakdown

1. BODY STRUCTURE

A.) UNDERSTRUCTURE
B.) FLOOR
C.) FLOOR LINING
D.) STEPWELL
E.) WHEEL HOUSING
F.) WHEEL HOUSING LINING
G.) FRONT BUMPER
H.) REAR BUMPER

2. BODY EXTERIOR

A.) DIMENSIONS
B.) EXTERIOR SIDE PANELS
C.) EXTERIOR ROOF PANELS
D.) WINDOWS
E.) DOORS
F.) EMERGENCY EXITS
G.) FINISH
H.) UNDERCOATING
I.) RUB RAILS AND TRIM
J.) MUD FLAPS

3. BODY INTERIOR

A.) INTERIOR DIMENSIONS
B.) INSULATION
C.) FLOOR PLAN
D.) SEATS
E.) INTERIOR SIDE PANELS
F.) INTERIOR CEILING PANELS
G.) FLOOR COVERING
H.) SAFETY RAILS AND STANCHIONS

4. DRIVER COMPARTMENT

A.) GAUGES AND DISPLAYS
B.) WARNING SIGNALS AND INDICATORS
C.) CONTROLS
D.) MIRRORS AND GLARE PROTECTION
E.) DRIVERS SEAT

5. ENVIRONMENT CONTROL

A.) PASSENGER COMPARTMENT HEATER
B.) FRONT HEATER
C.) AIR CONDITIONING

6. CHASSIS

A.) SPECIFICATIONS
B.) DIMENSIONS
C.) RATINGS - AXLES AND SUSPENSION
D.) TIRES
E.) BUS WEIGHT
F.) SUSPENSION
G.) BRAKES
H.) STEERING
I.) ENGINE
J.) TRANSMISSION
K.) FUEL SYSTEM
L.) COOLING SYSTEM
M.) EXHAUST SYSTEM
N.) ACCESS DOORS

7. ELECTRICAL SYSTEM

A.) BATTERY
B.) CHARGING SYSTEM
C.) WIRING

8. LIGHTING

A.) INTERIOR LIGHTING
B.) EXTERIOR LIGHTING

9. WHEELCHAIR LIFT/RAMP

A.) SPECIFICATIONS
B.) SAFETY FEATURES

10. SAFETY AND EMERGENCY EQUIPMENT

A.) FIRE EXTINGUISHER
B.) TRIANGLE WARNING DEVICE
C.) FIRST AID KIT
D.) HORN
E.) WINDSHIELD WIPER AND WASHER
F.) BACK UP ALARM
G.) HAZARD WARNING LIGHTS
H.) SPARE TIRE
I.) TOWING HOOKS

11.) PERFORMANCE SPECIFICATIONS

A.) TOP SPEED
B.) ACCELERATING
C.) DECELERATION
D.) BRAKING
E.) TURNING RADIUS OVER BODY
F.) TURNING RADIUS OVER TIRES
G.) INTERNAL NOISE LEVEL
H.) EXTERNAL NOIST LEVEL

the design to customer's request. Table 3 shows the bus manufacturers responding to the initial request and the type of buses for which specifications were provided.

Current State of The Art

Current state of the art is exemplified in current technology which could have an impact on bus design and method of construction. The purpose of this step was not as much to use the state of technology development as means for placing specifications ahead of the current state of design and to use this as a driving force to achieve improved design, as it was to assure that specifications do not exclude future developments in bus design based on current technology by default.

Literature review and contact with various bus manufacturers was necessary to determine available technology. Areas of expected new development based on current technology include, among other advances, the more extensive use of high impact plastic in special areas of the bus such as doors and bus interior, the use of brake retarder systems to help decelerate the bus and improve the life of the braking system, as well as, the use of air suspension to provide a smoother ride and reduce body swaying.

Other States Specifications

An effort has been made early in the study to obtain other states specifications. State specifications varied considerably in scope and coverage and tended in most cases to reflect the concerns and the problems encountered in the rural operating environment in the particular state in which the specifications are used. In addition, a close review was made of the various national forums used to discuss bus acquisition and specifications.

The purpose of this step was to assure that Arkansas small transit bus

TABLE 3: Bus Manufacturers and Available Specifications

BUS MANUFACTURER/ TYPE	BUS LENGTH/ WHEEL BASE	SEATING CAPACITY (MAX.)
AMTRAN		
VANGUARD - Body on Van Chassis		19
PATRIOT - Body on Truck Chassis		18 - 48
BLUE BIRD		
MT 30 - Special Built		31
BUS INDUSTRIES OF AMERICA		
ORION II - Special Built	21 ft.	18
	25 ft.	26
CARPENTER		
CADET - Body on Truck Chassis	125 in. W.B.	17 - 19
	133 in. W.B.	21 - 23
	157 in. W.B.	25 - 27
CHAMPION		
TRANSTAR - Body on Van Chassis	19 ft.	17
	22 ft.	22
	24 ft.	26
	28 ft.	30
COLLINS		
DODGE BANTAM - Mod Van		16
FIAT		
IVECO MINI BUS - Body on Chassis		16
IVECO BUS - Body on Chassis		19
FLXIBLE		
30' METRO - Special Built		32
THOMAS		
MIGHTY - MITE - Body on Truck Chassis	125 in. W.B.	18 - 23
	133 in. W.B.	22 - 28
	157 in. W.B.	26 - 33
TRANS BUS OF AMERICA		
STEYR CITY BUS - Special Built		15
TURTLE TOP		
TERRA TRANSIT - Body on Van Chassis		17 - 21
WAYNE		
BUSETTE - Body on Van Chassis		13 - 17
CHAPERSON - Body on Van Chassis		14 - 17

specifications complements rather than contradicts the specifications developed by other states. Major divergence from any general trend in other states specifications was adopted only after a reasonable justification. The advantage of this approach is to assure that bus manufacturers would not be required to modify present vehicles drastically to make it acceptable to Arkansas. This would provide for taking advantage of production scale and helps maintain a lower price.

The states for which specifications were obtained and the type of specifications are listed in Table 4.

Specifications

According to the flow chart, Figure 1, specifications are viewed as a dynamic entity which responds to the various inputs. Specifications are expected to be updated regularly and would take into account changes in current product and component design, advances in related technologies and actual field performance.

Field Performance

Field performance is the key to system, subsystem and component evaluation, and to the establishment and revision of bus specifications. Field performance is represented in the form of incidents of breakdown and repair cost. Fuel consumption and cost were not used in evaluating the operating performance because of inconsistencies in available data both on fuel consumption and prices. Overall national fuel consumption data is, however, available for the life cycle cost comparison purposes (3).

Field performance is grouped by vehicle type, model and year. They are expressed in the form of general findings concerning system reliability, maintainability, serviceability and ease of operation. The data is then contrasted to system design and conclusion concerning new design requirements and specifications are established.

Data collection form used in evaluating field performance is shown in Appendix A.

TABLE 4: State Specifications and Respective Coverage

1) CALIFORNIA: 16(b)(2) Program; 1983

   a) Cut-Away Cab Chassis - 16 Passenger
   b) Modified Van
   c) 20 - Passenger Bus with wheelchair lift
   d) 19 - Passenger Bus
   e) 24 - Passenger Bus

2) COLORADO: 16(b)(2) Program; Revised Jan 1984

   a) Modified Van - 12 Passengers
   b) Small Body on Chassis - 16 Passengers
   c) Large Body on Chassis - 20 Passengers

3) FLORIDA: 16(b)(2) Program; May 1983

   a) 16 - 18 Passengers
   b) 20 - 24 Passengers

4) INDIANA: 16(b)(2) Program; February 1984

   a) Vans
   b) Modified Vans
   c) Body on Chassis
   d) Small Buses

5) MICHIGAN: 16(b)(2) Program; March 1983

   a) Small Bus - 14 Passengers
   b) Medium Bus - 20 Passengers
   c) Large Bus - 32 Passengers

6) MISSISSIPPI: 1985

   (18 Passenger)

7) OHIO: 16(b)(2) Program; May 1984

8) CITY SPECIFICATIONS:

   a) MCDONALD TRANSIT ASSOC.: Fort Worth, Texas; 18 Passenger Bus
   b) CENTRAL ARKANSAS TRANSIT: Little Rock, AR; 17-23 Passenger Bus

SMALL TRANSIT BUSES IN ARKANSAS

In the process of reviewing performance and developing specifications, it is important to recognize the nature and make-up of the small transit bus fleet in Arkansas. the fleet make-up is a result of current bus acquisition practice and would be indicative of current trend and need for various types of vehicles.

A compilation of the current small transit buses in Arkansas was made in July, 1985, and is analyzed in Figures 2, 3, and 4. Figure 2 shows the small transit bus fleets for Sections 16(b)(2) and 18 classified according to vehicle type and model year. The type classification is the same as that used in Reference (3). Figure 3 shows the vehicle make, model and year for Section 16(b)(2) program vehicles, and Figure 4 shows the same for Section 18 vehicles. Analysis of the data in Figure 2 shows that Section 16(b)(2) vehicles are heavily weighted in favor of vans and modified vans which represent 65% of the total. The remainder, represents body on van chassis (22%) and body on a truck chassis (13%). The more recent trend in vehicle acquisition shows a move towards purchasing less vans, modified vans and body on truck chassis and more of the body on van chassis. These results coincide with the findings during the survey of a sample of fleet operators around the state in the Summer of '85. The survey indicated that Section 16(b)(2) operators consider low cost, simplicity, ease of operation and maintenance as the advantage of vans and modified vans, while on the other hand limited space, narrow aisles, low ceiling and difficulty of access particularly for the elderly and handicapped are their disadvantage. Most, who have sufficient ridership would prefer a body on van chassis type particularly if the operating and maintenance performance of the vehicle are acceptable.

The decline in the acquisition of body on a truck chassis type vehicle is a result of the realization that the size and bulkiness of these large buses outweigh the additional capacity advantage in a predominantly demand type service. In addition, the high maintenance cost associated with these buses would have a serious negative impact on operating budgets of the small service agencies of Section 16(b)(2). Large vehicle capacity would also tend to limit the operating flexibility under such circumstances.

Vehicle make and model for Section 16(b)(2), Figure 3, is dominated by the Dodge Van which represents 47% of the total followed by Wayne Busette and Ford Van representing 13% and 11% respectively. This is not, as we understand it, a result of any natural selection process more than it is an artifact of the degree of emphasis those bus manufacturers place on participating in the transit fleet market in Arkansas.

Section 18 fleet make-up, Figure 3, is dominated by the body on a truck chassis type buses which represent 49% of the total. More recent trend is showing a move towards the body on van chassis, special built and even standard vans and modified vans. This reflects to some degree the realization that size, durability, fuel economy and susceptibility to frequent repairs are causing body on truck chassis type buses to become a less favorable alternative for rural transit in Arkansas. Considering the make and model of Section 18 buses, Figure 4, we find that superior GMC (bought used by the city of Hot Springs) represents 25% of the total followed by the Dodge Van which represents 15% in the second place. The more recent acquisition of buses seems to be divided among various makes and models. The second place of the Dodge Van is an indication of the penetration of the van in the rural transit market.

Figure 2: Small Bus Type for The State of Arkansas (July 1985)

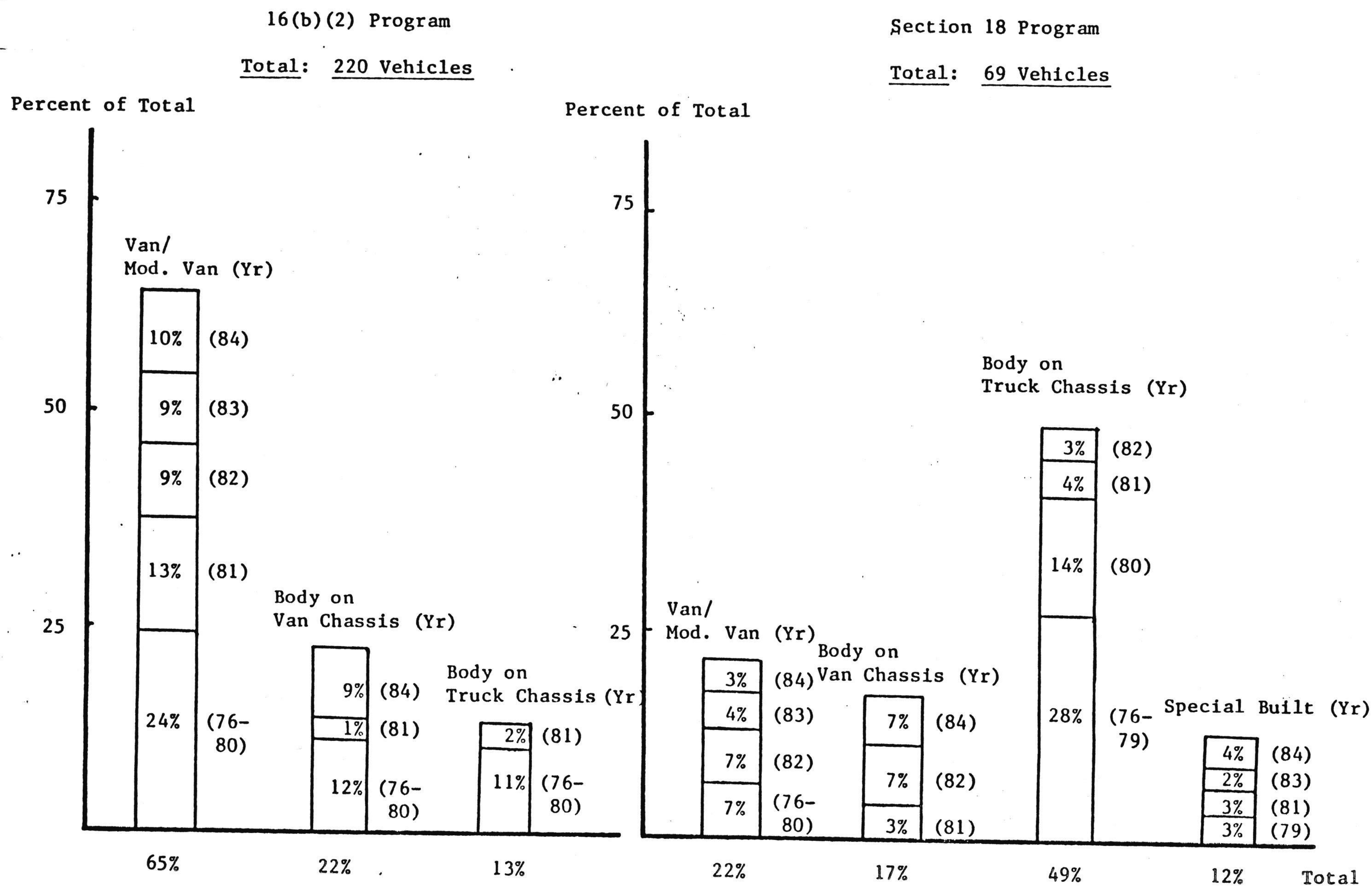


Figure 3: Small Bus Make, Model and Year For The State of Arkansas (Section 16(b)(2) - Total: 220 Vehicles)

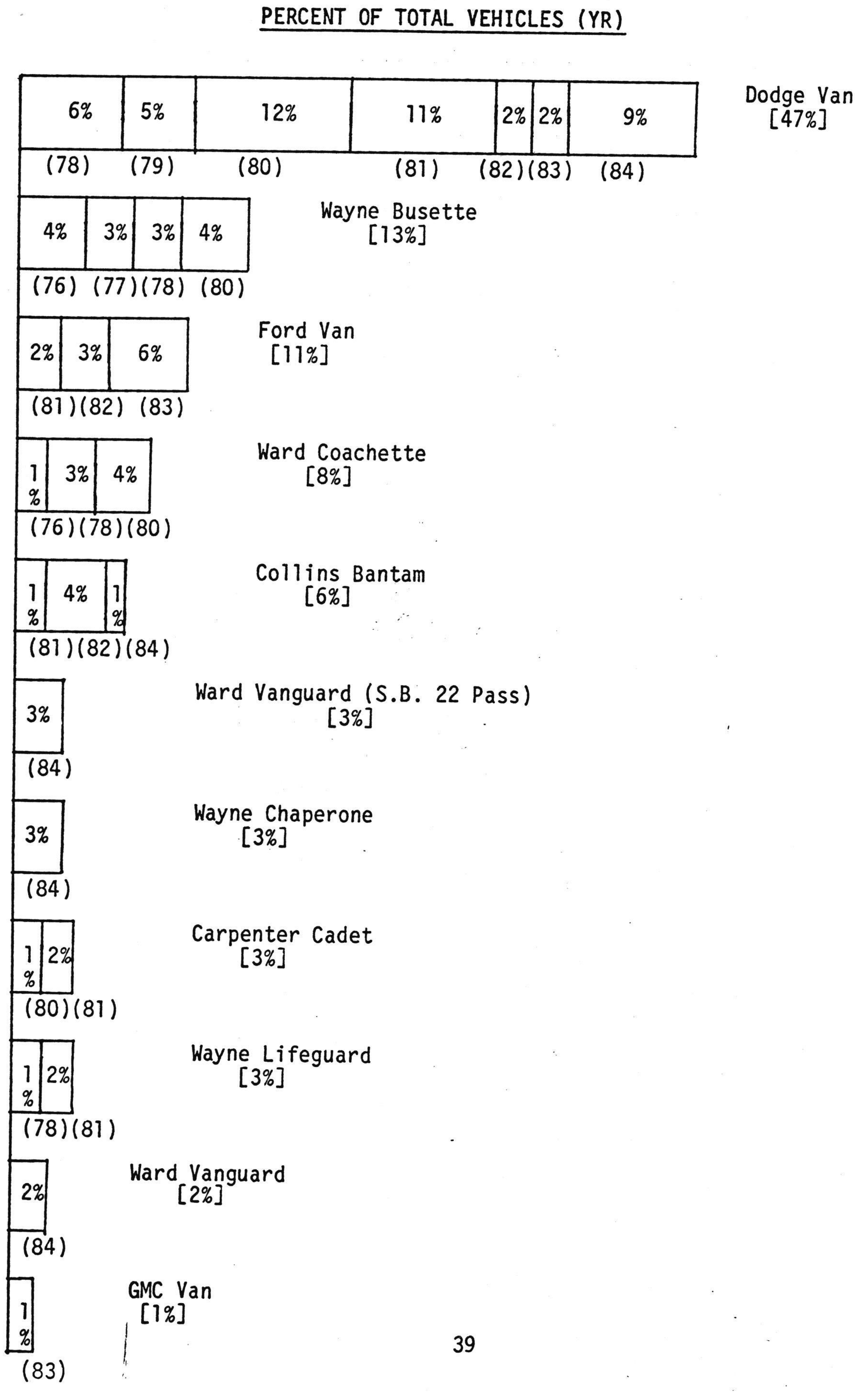
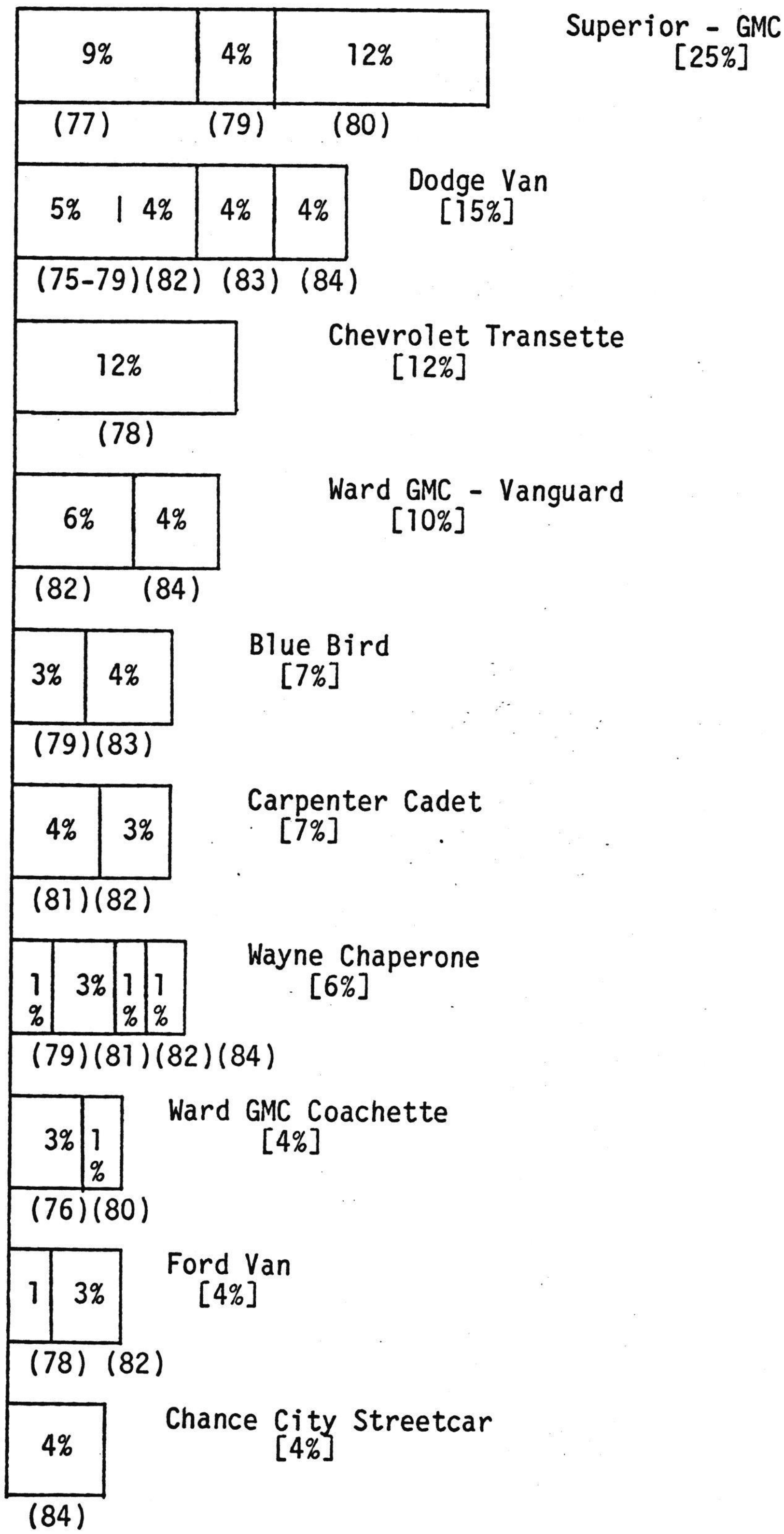


Figure 4: Small Bus Make, Model and Year For The State of Arkansas (Section 18 - Total: 69 Vehicles)

PERCENT OF TOTAL VEHICLES (YR)



Bus Performance

Bus performance data was collected from both Sections 16(b)(2) and 18 operators according to the data collection forms included in Appendix A. Performance data of current vehicles was requested for the last two years. This provided sample data concerning various vehicles at different stages of their useful life. While the data is considered reliable because of age and sample distribution over a number of vehicles, it did however leave some gaps in the bus life mileage range.

Figures 5, 6, and 7 show the maintenance cost per mile over the bus life for various types of buses and associated severity of service. The maintenance cost average was 11.64 cents/mile for a body on van chassis operating at a moderate duty cycle, 21.46 cents/mile for body on truck chassis operating at a moderate duty cycle, and 28.75 cents/mile for the same type operating at a severe duty cycle. Maintenance cost for purpose-built bus operating at a severe duty cycle was 16.4 cents/mile. The previous data on maintenance cost/mile was generally less than that derived from the data provided in reference (3) which would represent the national average. The general relationship of the maintenance cost was however the same, that is: body over van chassis was the lowest followed by purpose-built, body on truck chassis - moderate duty cycle, and body on truck chassis - severe duty cycle.

Tables 5, 6, 7 and 8 contain the summary data on frequency and type of repairs for various vehicles operating at respective duty cycle for various mileage segments over the life of the bus. Data concerning body on van chassis operating at a moderate duty cycle, Table 5, shows that the highest frequency is for engine repairs, followed by the electrical system, drive train, air conditioning, suspension, brakes and miscellaneous. Engine and electrical system repairs occur approximately twice as often as those for the drive train. Body on truck chassis operating at moderate duty cycle shows a higher overall average frequency of repairs. The highest frequency of system repair was for the engine followed by electrical system, air conditioning, brakes, suspension, drive train, body and miscellaneous. The same type of bus operating at a severe duty cycle, Table 6, shows approximately double the frequency of repairs for brakes. Purpose-built buses, Table 7, show the lowest overall average frequency of repair of all small transit buses by far. The data on Table 7 is, however, limited to a 70,000 miles life which would be expected to yield fewer repairs in comparison to that covering the full life of the purpose-built bus which can reach one million miles.

The previous data provides a helpful guide in the development of small bus specifications and in identifying basic bus systems which are in need of improvement. The thrust of current bus specification must also take into account the current state of development in engine, drive train and other bus systems technology. The state of development reflects the current state of the art, as well as, the degree of progress made by bus manufacturers in applying the state of the art to current product design. The degree of application is indicative of the economic and practical feasibility of the new technology.

Figure 5: Maintenance Cost (Cents Per Mile)

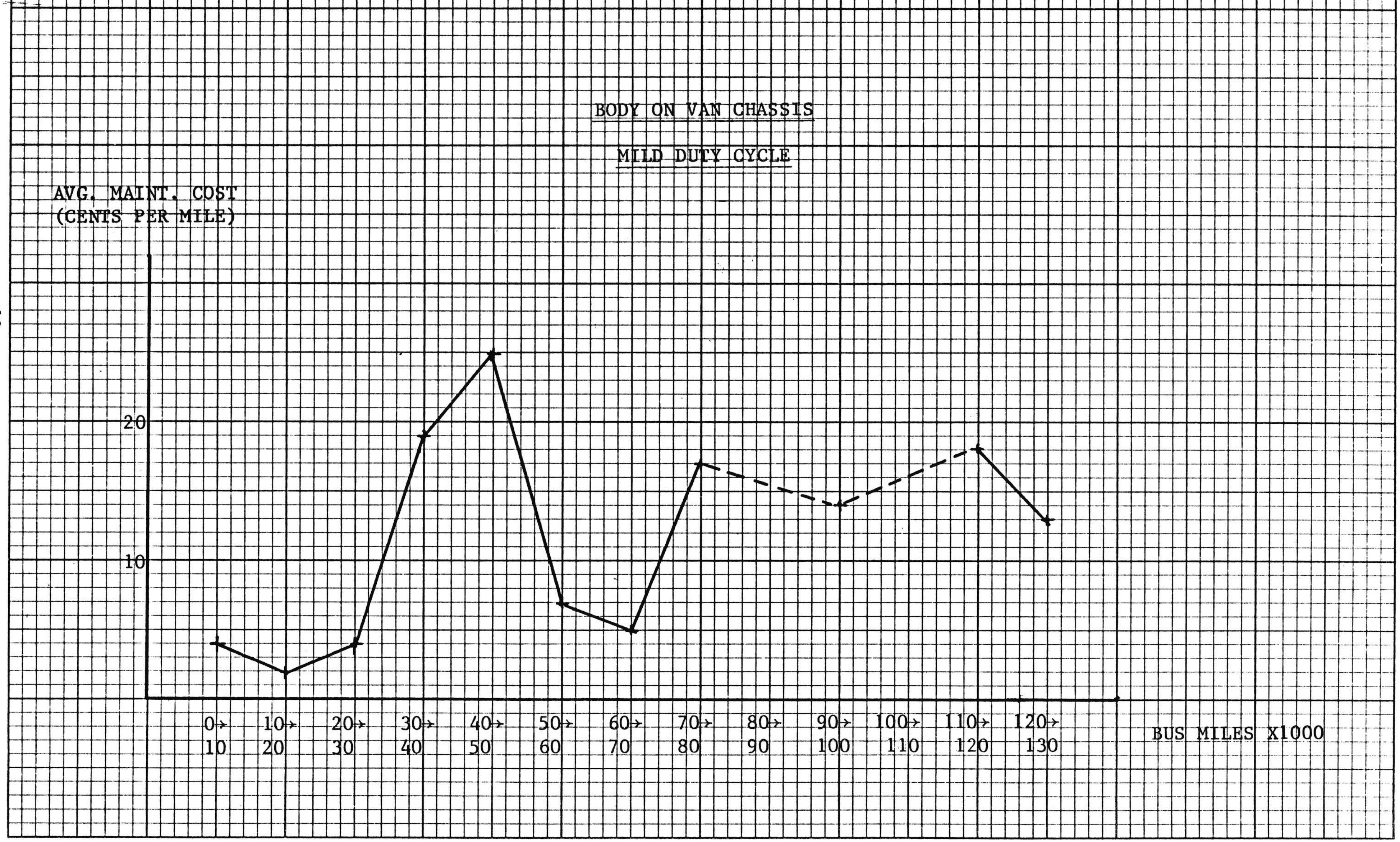


Figure 6: Maintenance Cost (Cents Per Mile)

BODY ON TRUCK CHASSIS

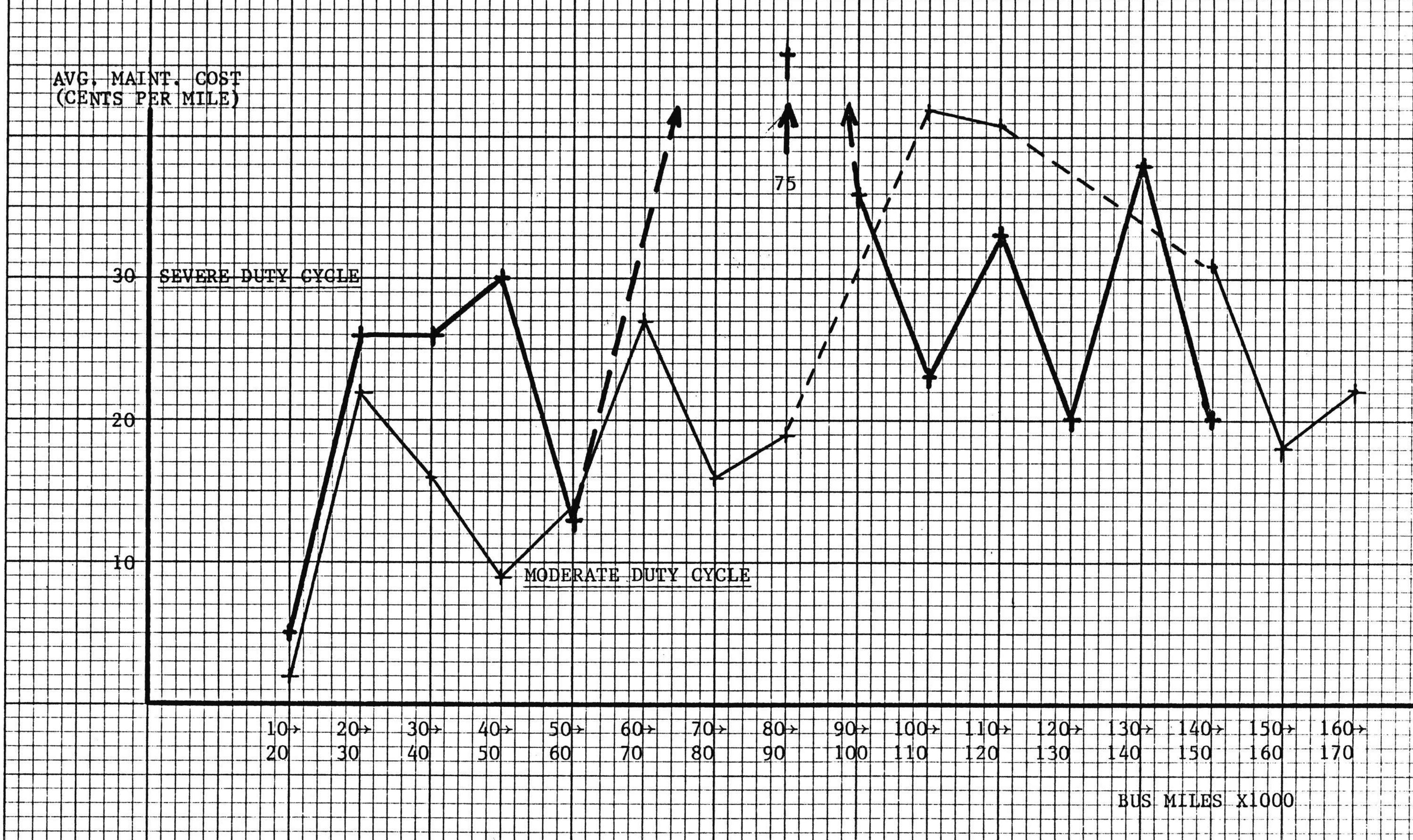


Figure 7: Maintenance Cost (Cents Per Mile)

SPECIAL BUILT

SEVERE DUTY CYCLE

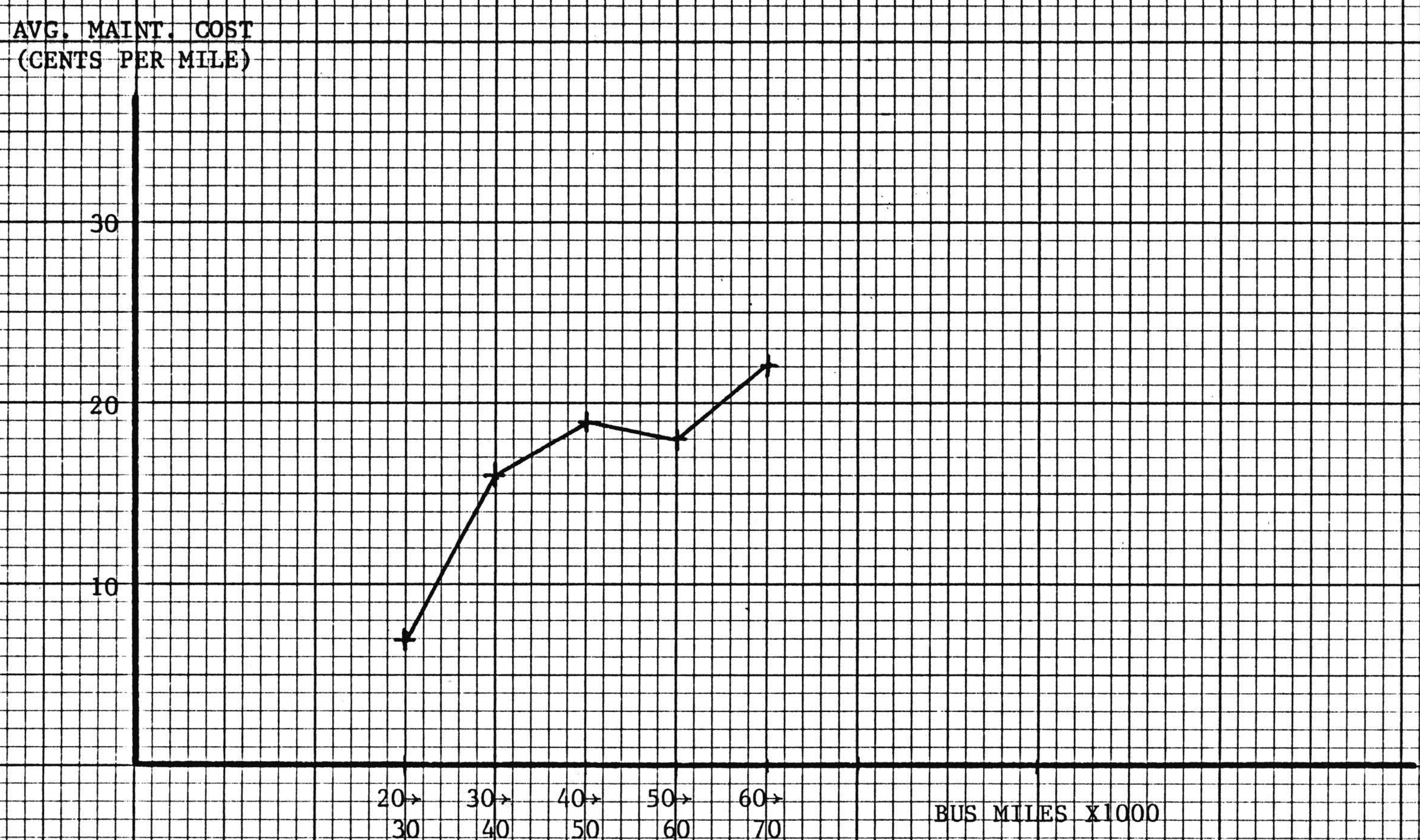


TABLE 5: Expected Number and Type of Repairs Per Vehicle Over Stated Mileage Segments

Body On Van Chassis - Moderate Duty Cycle

Body	0.14	--	--	--	--	0.33	--	--	N/A	--	N/A	1	--	0.13	
Engine	0.43	--	1	3	0.5	1	0.67	2	N/A	2	N/A	2	2	1.33	water pump, cylinder head cam shaft, & engine replacement
Drive Train	--	--	--	1	0.5	--	1	--	N/A	2	N/A	1	2	0.63	axle overhaul & u-joints
Brakes	0.14	--	--	--	--	0.33	0.67	1	N/A	--	N/A	--	2	0.38	
Suspension	0.29	0.75	--	1	--	0.33	--	--	N/A	2	N/A	1	--	0.49	stabilizer bar, wheel bearings, tie rods
Air Cond.	--	--	--	1	1	1.67	1	1	N/A	--	N/A	--	--	0.52	
Elec. Sys.	0.86	0.25	0.67	2	0.5	0.33	1	--	N/A	4	N/A	1	3	1.24	Altenator,...
Misc.	0.43	0.5	--	--	0.5	0.67	0.33	--	N/A	1	N/A	--	--	0.31	Tires
Total	2.29	1.5	1.67	8	3	4.66	4.67	4	N/A	11	N/A	6	9	5.03	
Mileage Segment X1000	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-110	110-120	120-130	Avg./Seg.	

TABLE 6: Expected Number and Type of Repairs Per Vehicle Over Stated Mileage Segments

Body On Truck Chassis - Moderate Duty Cycle

Body	--	2	--	--	0.5	--	0.5	0.5	N/A	1	--	N/A	N/A	--	--	2	0.5
Engine	1	1	--	1.8	1.75	1.75	2	1.5	N/A	5	5	N/A	N/A	3	--	2	1.98
Drive Train	--	2	1	0.4	0.75	0.25	0.5	--	N/A	1	2	N/A	N/A	--	--	2	0.76
Brakes	--	1	--	0.2	0.25	1.25	0.5	--	N/A	3	1	N/A	N/A	1	1	2	0.86
Suspension	1	--	--	0.4	0.75	0.25	0.5	1	N/A	2	2	N/A	N/A	1	2	--	0.84
Air Cond.	--	1	1	0.8	0.75	0.25	--	1.5	N/A	3	2	N/A	N/A	2	--	1	1.02
Elec. Sys.	1	1	--	1.6	1.25	1.5	2	1.5	N/A	--	4	N/A	N/A	3	2	2	1.53
Misc.	--	--	0.5	0.2	0.25	0.5	1	1.5	N/A	--	2	N/A	N/A	--	--	--	0.46
Total	3	8	2.5	5.4	6.25	5.75	7	7.5	N/A	15	18	N/A	N/A	10	5	11	7.95
Mileage Segment X1000	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-110	110-120	120-130	130-140	140-150	150-160	160-170	Avg./Seg.

TABLE 7: Expected Number and Type of Repairs Per Vehicle Over Stated Mileage Segments

Body On Truck Chassis - Severe Duty Cycle

Body	--	--	1	--	--	N/A	N/A	1.25	1.33	--	--	0.75	1	--	N/A	N/A	0.36
Engine	--	2	4	2.5	--	N/A	N/A	3.5	2.33	1.5	2	1	2	1	N/A	N/A	1.82
Drive Train	1	--	1	--	--	N/A	N/A	1.25	0.67	0.5	0.2	0.25	--	--	N/A	N/A	0.41
Brakes	1	2	3	3.5	1	N/A	N/A	1	2.33	0.5	0.6	1	1.5	2	N/A	N/A	1.62
Suspension	--	--	0.67	0.5	--	N/A	N/A	1	1.33	1	1	0.5	--	--	N/A	N/A	0.50
Air Cond.	--	--	2.67	2	1	N/A	N/A	0.5	0.67	1.5	1.2	0.75	1	--	N/A	N/A	0.94
Elec. Sys.	2	4	1.67	0.5	--	N/A	N/A	1.75	1.67	1.25	3.8	1.5	1	4	N/A	N/A	1.93
Misc.	--	3	--	--	--	N/A	N/A	0.75	0.67	0.5	0.8	0.25	1	--	N/A	N/A	0.58
Total	4	11	14.01	9	2	N/A	N/A	11	11	6.75	9.6	6	7.5	7	N/A	N/A	8.16
Mileage Segment X1000	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-110	110-120	120-130	130-140	140-150	150-160	160-170	Avg./Seg.

TABLE 8: Expected Number and Type of Repairs Per Vehicle Over Stated Mileage Segments

Special Built - Severe Duty Cycle

Body	--	--	0.67	0.33	--	0.13	Doors
Engine	--	2	1	1.67	1.33	0.20	Alt. Belt, Water Pump, Steering Pump
Drive Train	--	--	0.67	--	1.67	0.07	U-Joints, Drive Shaft
Brakes	--	1	1	2.67	2	0.4	Shoes, Seals, Anti-skid Sensor
Suspension	--	0.5	0.67	1	1	0.07	Air Bag, Sway Bar, Bushing
Air Cond.	--	--	1	0.67	1	0.4	Motor, A/C Switch
Elec. Sys.	--	1	1.33	1.67	1	0.27	Alternator, Horn, Lights & Turn Signals
Misc.	--	0.5	0.33	0.33	--	0.13	Lift, Tires
Total	--	5	6.67	8.34	8	1.67	
Mileage Segment X1000	20-30	30-40	40-50	50-60	60-70	Avg./Seg.	

SMALL TRANSIT BUS OPERATING PROBLEMS AND OUTLINE OF SPECIFICATIONS AREA

The survey conducted in the current study of small transit buses in Arkansas provided a broad profile of various problem areas encountered in small bus operation and maintenance. The profile has been compiled from the data collected by the questionnaire included in Appendix A and mailed to all Sections 16(b)(2) and 18 operators. Data has been compiled for all buses regardless of type. The problem areas identified represent, therefore, those encountered in a general cross-section of small buses which include body on a van chassis, body on a truck chassis and purpose-built. The data is, however, heavily weighted in favor of the body on van chassis because of their large share of the total fleet. Data on vans and modified vans were not included in this profile.

The purpose of establishing a profile of operating and maintenance problem was to assure that specifications and/or acquisition procedure would be planned to counter these problems and to assure that such problems would, to the extent possible, be "speced out" of the bus. It also provided an acceptable grounds to discuss the specifications with bus manufacturers and to involve them in solving current problems through the development of acceptable specifications that would be economical to implement. Table 9 provides a compilation of the various problem areas and the specification response to these problems.

TABLE 9: Small Bus Problem Areas and Specification Response

PROBLEM AREAS	SPECIFICATIONS
1. Bus leaks water (around windshield). Windows do not seal well.	1.1 Require appropriate sealing methods and materials that does not deteriorate with time.
	1.2 Require a water leak test before delivery.
2. Doors (manual)are difficult to operate	2.1 Require a maximum force to operate the door
3. Doors rattle and do not seal well	3.1 When door is closed it is held with against a resilient material or a spring force to reduce vibrations and rattling.
	3.2 Appropriate sealing rubber materials (............) should be applied to the door edges and between door segments to assure proper seal.
4. Body rattles and rivet failure occurs.	4.1 Bus body should consist of an integrated structural unit which consists of skeleton capable of carrying and distributing the load on the body to appropriate structural member and ultimately to the vehicles chassis.
	4.2 For buses built by attaching outer skin to structural members of the body the use of blind (pop) rivets is to be avoided or minimized in constructing the previous assembly.
5. Paint chips, peels or fades.	5.1 Paint materials and procedure specs.
6. Walk space is not adequate. Stanchions are placed where they would interfere with passenger and wheelchair movement.	6.1 Establish guideline for bus layout plans, taking into account wheelchair, passenger and others as necessary (.........). Plan would require main aisle width (..........) circulating space behind doors (............) and guidelines for placement of stanchions and grab bars (.........).
7. Inadequate hip and leg room.	7.1 Require min. seat clearance for leg and hip space (.......,.........)
Inadequate head room at certain locations	7.2 Require min. inside height at door, at aisle and over seat area (............,...........,..........)
	7.3 Require min, door width, height, step height, and max distance between ground level and the first step (............, ..., ...).
8. Spare tire is not properly placed and secured in the bus.	8.1 Require that spare tire be placed and secured where it would not interfere with passenger traffic or seating and at the same time would be easily accessible for removal to replace a flat tire.
9. Upholstery material is light and seats are not properly upholstered.	9.1 Require a min. thickness (quality) of upholstery material and seat design. (...).
10. Heater capacity is not large enough for bus	10.1 Require min. heater capacity based on bus size (..).
	10.2 Require the use of two unit heaters, one in the front and the second in the back.
11. Air conditioning unit is not large enough for the bus.	11.1 Require min. unit size based on bus capacity (...............)
	11.2 Require tinted glass for all windows (35% pass through light ....).
	11.3 Require min. insulation in ceiling walls and bus ends (1 1/2 in fiberglass bats.......................................).
	11.4 Require min. floor insulation (.............................)
	11.5 Require bus undercoating for rust proofing, insulation and sound deadening (..)
12. Air conditioning unit requires frequent repairs.	12.1 Require the use of field attachable screw style hose end clamps according to SAE J 516 for refrigerant hoses.

TABLE 9: Small Bus Problem Areas and Specification Response (cont'd)

PROBLEM AREAS		SPECIFICATIONS	
	Major Source of Problems: - Refrigerant leakage (primarily from hose connections). - Belt become loose. - Evaporator breaks loose from mounting. - Evaporator leaks water on passengers.		
		12.2	Provide installation guidelines for routing and protecting refrigerant and drain hoses, and electrical wiring.
		12.3	Require the installation of a low and high pressure cut-off relay and warning system.
		12.4	Require that the evaporator be mounted to the bus structural members (bows) of the bus.
		12.5	Provide for proper bracing to support the weight of the evaporator and to distribute it over appropriate load bearing members of the structure.
		12.6	Require two (front & rear) for mid-bus mounted evaporator or right-forward and left-backward mounted drain hoses to help remove water condensate.
13.	Skirt mounted condenser and skirt mounted engine collect dust quickly on dirt roads which plugs condenser, chokes the engine and limits the capability of the air conditioning unit.	13.1	Provide a special duct and mount the air intake for engine driven units in an area away from the dust generated under the bus.
		13.2	Provide a ducting with necessary baffle to eliminate or reduce the accumulation of dust on the condenser.
	Air conditioning does not cool enough at idle speed where the bus is not traveling.	14.1	Provide for the installation and use of an idle speed booster which would be activated when A/C is turned on, vehicle transmission is in neutral and engine is at idle speed.
15.	GVWR does not provide sufficient capacity for passenger and luggage.	15.1	GVWR must allow for the number of stated adult passengers times 250 lbs, students times 100 lbs to allow for carry on luggage. Additional equipment such as chair lifts, wheelchairs, ...ect., must be taken into account separately.
16.	Brake lining requires frequent replacement.	16.1	Require the use of heavy duty brakes.
		16.2	Require the outfitting of a brake retarder. (Tentative)
17.	Suspension does not provide a comfortable ride.	17.1	(Chassis manufacturer)
18.	Engine is not adequate for the bus. - Engine requires frequent repairs.	18.1	Require min. performance standards for engine
		18.2	Require a large capacity cooling system.
	- Engine cooling is not adequate.	18.3	Require a separate engine oil cooler.
19.	Transmission requires frequent repairs.	19.1	Require the use of a heavier duty transmission.
		19.2	Require the use of transmission oil cooler.
20.	Alternator is not large enough.	20.1	Require the use of 80 Amp. alternator for a standard vehicle, 130 Amp. alternator for a vehicle with A/C and 150 Amp. alternator for a vehicle with A/C and chair lift.
21.	Electrical system requires frequent repairs.	21.1	Require min. battery size (.............................).
		21.2	Require main power disconnect switch.
		21.3	Require auxiliary equipment overload relay and power disconnect switches.
		21.4	Require bulk head disconnect and auto type connections for body wiring. Wiring should be color coded and connection sealed in moisture tight enclosures.

BUS MANUFACTURERS RESPONSE TO SPECIFICATIONS

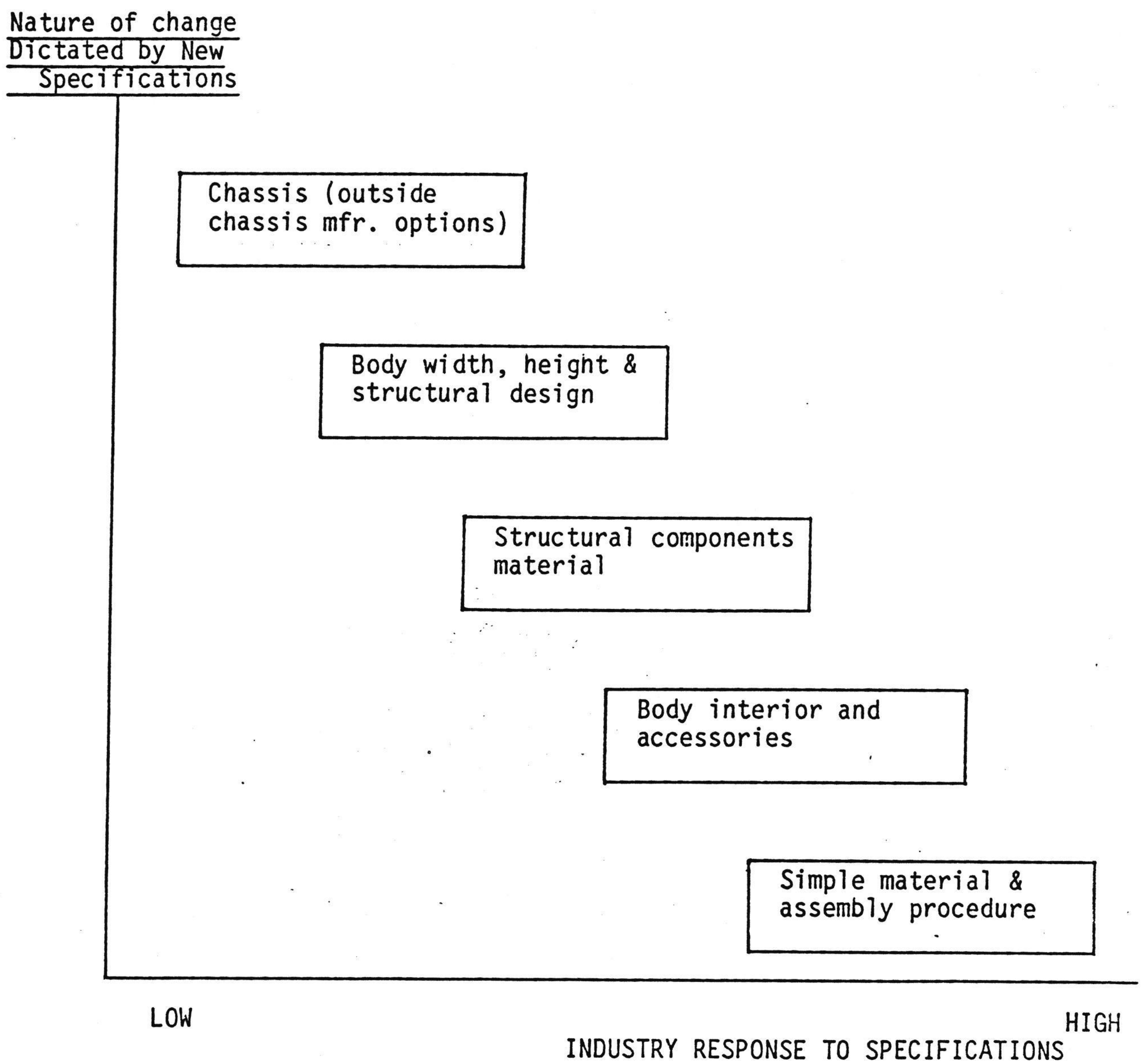
Contacts made with small bus manufacturers showed a considerable degree of flexibility to respond to specifications. This is influenced to some extent by the current manufacturing methods used in the industry. Such methods would be recognized as a combination of manual and semi-antomatic which is not capital intensive. This allows a relatively high degree of flexibility in accommodating design changes without incurring high capital cost.

The degree of manufacturer flexibility in accommodating new specifications is, however, a function of the extent to which the new specifications would influence current manufacturing methods and procedures. Changes requiring, for example, simple material and assembly procedure changes could be implemented easily and at a reasonable cost. On the other hand, changes which would require major tooling and production set-up changes are likely to be resisted and if implemented would require investment in tooling, equipment and would be subject to a significant lead time and price increase.

Although the industry would ultimately respond to changes dictated by vehicle specifications, the potential for response, lead time and ultimate cost to the user are likely to be a function of the degree of change and the extent to which the new specifications would be adopted. The wider the adoption of such specifications in the transit market the greater the probability of industry response to the new specifications. This experience has been encountered before in the implementation of new specifications for the large size urban transit bus, when large consolidated purchase contracts were awarded to provide incentive for bus manufacturers to invest in new tooling and equipment so that the new buses could be introduced in the field. Figure 8 shows the expected response to new specifications as a function of the degree of change dictated by the specifications.

Most small bus manufacturers and accessory equipment suppliers, who were contacted during the course of the study, indicated that the approach used in the current study, namely the use of feedback concerning vehicle performance as a basis for developing specifications, is the most plausable and acceptable method for developing and modifying small bus specifications. The wide adoption of the specifications would also provide a special impetus for the response of industry to the new specifications.

FIGURE 8: Small Bus Industry Response to New Specifications



FINDINGS AND CONCLUSIONS

The procedure outlined in this report provides a systematic approach for the development and updating of small bus specifications. The basic premise of this approach is to maintain and use feedback data regarding vehicle system, subsystem and component performance in defining problem areas, and to establish , along with the bus manufacturer, engineering solutions and specifications to correct these problems. A degree of specification uniformity among states is also desirable to assure an economic production scale and lower cost.

The role of statistical performance data that would provide a profile of the problem areas and could be used as a basis for the development of specifications could not be overemphasized. Data for the current study was collected from existing maintenance records which were not as complete as would be desirable in the long run. The bus system breakdown Table 2 provides a foundation that can be used for identifying the sources of maintenance problems. Contacts with the manufacturers and additional detective work may be necessary to establish engineering solutions and revise the current specifications in the future.

It is also important that a forum be established for the joint assembly of officials responsible for fleet maintenance and those involved in small bus acquisition to identify desired changes in specifications and acquisition procedure.

APPENDIX A

Performance and Maintenance Survey Questionnaire

UNIVERSITY OF ARKANSAS AT LITTLE ROCK
33RD AND UNIVERSITY · LITTLE ROCK, ARKANSAS 72204 · 501/569-3148

SCHOOL OF
ENGINEERING TECHNOLOGY

Ref: Standard Specifications for Small Transit Buses.

Dear Mr.

In an effort to improve the quality and service of small transit buses in the state of Arkansas, The School of Engineering Technology at UALR is undertaking a project for the Arkansas Highway and Transportation Department to devleop standard specifications for small buses (16-24 passengers, up to 32 passengers when seating plan accommodates wheelchair passengers). To be able to achieve our goal we must learn as much as we can about the merits and problems of current equipment. Therefore, we wish to request that you provide us with the following information on the buses in your fleet which fall in the above category (16-32 passengers):

1. Bus Information
2. Bus Evaluation
3. Chronological Maintenance Record, which is a summary of maintenance work performed on the bus during the past two years (Example shown at the beginning).

(1) and (2) may be prepared for each bus, or for a group of similar buses performing similar service, (3) must be prepared for each bus. Additional comments and information regarding modifications that you made to original equipment and desired specifications are also sought.

We appreciate your cooperation and we will be looking forward to receive the completed forms, within two weeks since we expect to use the data immediately.

If you have any questions please do not hesitate to cal Mo Bakr or Bill Swab at 569-3148 (work) or Mo Bakr at 562-4728 (home).

Thank you in advance for your cooperation.

Sincerely,

M. M. Bakr
Professor

MMB/rm

Enclosures(Forms may be duplicated for additional space)

CHRONOLOGICAL MAINTENANCE RECORD

AGENCY:____________________ BUS ID:____________________

Maintenance Code:
Routine P/M: 1 Inspect/Adjust: 2 Repair: 3 Replace/Overhaul: 4

Maintenance By:
In-House: 1 Service Station: 2 Shop (local): 3
Dealer (out of town): 4

MFC: Monthly Fuel Cost
MMC: Monthly Maint. Cost

E YR	BEG. & END. MILES MFC & MMC	MAINTENANCE			REMARKS
		CODE	BY	DESCRIPTION	

BUS EVALUATION

ORGANIZATION:______________________ BUS ID(S):________________________

Please check the response which best describes the performance over the life of the Bus.

		YES	NO	SOMEWHAT
1)	Cracks or breaks occurs in the frame.	☐	☐	☐
2)	Body attachment to frame is not adequate.	☐	☐	☐
3)	Bus leaks water (if yes indicate locations): ____________________	☐	☐	☐
4)	Windows stick or are difficult to operate.	☐	☐	☐
5)	Windows do not seal well.	☐	☐	☐
6)	Doors are difficult to operate.	☐	☐	☐
7)	Doors rattle or do not seal well.	☐	☐	☐
	Body rattles and/or is subject to rivet failure.	☐	☐	☐
9)	Paint peels, flakes, or fades easily.	☐	☐	☐
10)	Bus needs better rust protection, if so, explain: ____________________	☐	☐	☐
11)	Bus floor plan accommodates passengers comfortably.	☐	☐	☐
12)	Head Room is adequate.	☐	☐	☐
13)	Access is easy to doors and passenger seats.	☐	☐	☐
14)	Upholstry wears out fast.	☐	☐	☐
15)	Floor covering works lose/wears out fast.	☐	☐	☐
16)	The following additional gauges, displays and alarms would be beneficial to the bus operator: ____________________			
17)	Heater Capacity Is not large enough to provide comfortable environment.	☐	☐	☐
18)	Air conditioning unit not large enough for the Bus.	☐	☐	☐

		YES	NO	SOMEWHAT
19)	What is the main re-occuring repair(s) on the air conditioning system? ______________________			
20)	GVWR provides sufficient capacity for passengers and carry on baggage.	☐	☐	☐
21)	Front brake linings require frequent replacement.	☐	☐	☐
22)	Rear brake linings require frequent replacement.	☐	☐	☐
23)	Braking performance of the Bus is adequate.	☐	☐	☐
24)	Suspension provides a comfortable ride. If not, explain. ______________________	☐	☐	☐
25)	What is the main re-occuring repair on the suspension? ______________________			
26)	Vehicle has a good steering control.	☐	☐	☐
27)	Steering power assist is adequate.	☐	☐	☐
28)	Steering requires frequent adjustment. If yes explain. ______________________	☐	☐	☐
29)	Vehicle turning radius is acceptable.	☐	☐	☐
30)	Engine is adequate for the Bus.	☐	☐	☐
31)	Engine requires frequent repair. If yes, explain. ______________________	☐	☐	☐
32)	Transmission is adequate for travel speeds and Bus load.	☐	☐	☐
33)	Transmission requires frequent repairs. If yes, explain. ______________________	☐	☐	☐
34)	Cooling system is adequate to avoid overheating problems.	☐	☐	☐
35)	Cooling system requires frequent repairs. If yes, explain. ______________________	☐	☐	☐
36)	Alternator/Generator has large enough capacity for the electrical system.	☐	☐	☐
37)	Electrical system requires frequent repairs. If yes, explain. ______________________	☐	☐	☐

38) Wheelchair lift/ramp:

Briefly explain the main re-occuring repairs on the lift/ramp.____

____

39) From past experience we prefer wheelchair lift over ramp. If no, explain.______________________________________

____

REFERENCES

1. Aboudara, Deane and Michael Krieg, "Application of Engineered Materials for Innovative Bus Design", SAE. Paper No: 811275.

2. Arkansas State Highway and Transportation Department, "1983 Annual Report, Public Transportation Unit," AHTD, Little Rock, Arkansas, October, 1983.

3. Boghani, A. B. et al, "Small Transit Vehicles; How to Buy, Operate and Maintain Them", NCTRP Report #11, Transportation Research Board, Washington, D.C., January, 1985.

4. Bureau of Urban and Public Transportation, Michigan Department of Transportation, "New Bus Equipment Introduction Program for Small Buses - Request for Quotation," Michigan, DOT, August, 1983.

5. Cook, A. R. et al, "Life Cycle Costing in the Transit Industry", Paper presented at The Transportation Research Board Sixty-Fourth Annual Meeting; Washington, D.C., January, 1985.

6. Dynatrend, Inc., "Small Transit Vehicles, Conference Summary," UMTA, Office of Technical Assistance, Washington, D.C., October, 1982.

7. Glasser, Howell S., "Listing of New Bus Technology Applications", National Technical Information Service, PB-84-149988, Springfield, VA, December, 1983.

8. Kaulback, P. "Transit Vehicle for the Disabled, Summary Report", Transportation Development Center, Montreal, Quebec, April, 1983.

9. Knudtson, John E., "Winnebago Front Wheel Drive Motor Home Design and Assembly," SAE Technical Paper Series, No. 841685, Truck and Bus Meeting and Exposition, Dearborn, Mich., December, 1984.

10. Lemke, Ronald D., "An Evaluation of Transit Bus Air Conditioning Systems", SAE, Paper No. 750402, Automotive Engineering Congress and Exposition; Detroit, Mich., February, 1975.

11. Limpert, Rudolph, "An Investigation of Integrated Retarder/Foundation Brake System for Commercial Vehicles," SAE, Paper No.: 750126, Automotive Engineering Congress and Exposition, Detroit, Mich., 1975.

12. Mateyka, James A., "Safety Considerations in Design of New Transit Bus Seats", SAE, Paper No. 741178.

13. Meacham, D. G. et al., "Specifications for Elderly & Handicapped Passenger Transportation Vehicles", UMTA, U.S. DOT,Washington, D.C., May, 1983.

14. "Meeting Highlights - Small Vehicle Procurement Workshop," Technical Assistance Briefs, UMTA, U.S. DOT, 1984.

15. Michigan Department of Transportation, "Small Bus Program: Vehicle Operating Efficiency", National Technical Information Service, PB-265-131, Springfield, VA, November, 1976.

16. Public Technology, Inc., "Bus Noise Reduction", Transit Technology Briefs, Vol. 1, No 2, Urban Consortium Transportation Task Force, Washington, D.C., July, 1981.

17. Public Technology, Inc., "Bus Brake Retarders", Transit Technology Briefs, Vol. 1, No 4, Urban Consortium Task Force, Washington, D.C., September, 1981.

18. Public Technology, Inc., "Small Transit Vehicles," Transit Technology Briefs, Vol. 1., No. 9, Urban Consortium Task Force, Washington, D.C., March, 1982.

19. RRC International, Inc.,"Study Transit Bus Requirements Study - Operations of Small Buses in Urban Transit Service in the U.S.", UMTA, U.S. DOT, Washington, D.C., July, 1975.

20. RRC International, Inc., "Bus Characteristics Needed for Elderly and Handicapped in Urban Travel, UMTA, U.S. DOT, Washington D.C., March, 1976.

21. RRC International, Inc., "Small Transit Bus Requirements Study - Operating Profiles and Small Bus Performance Requirements in Urban Transit Service", UMTA, U.S. DOT, Washington, D.C., December, 1976.

22. RRC International, Inc., "Small Transit Bus Requirements Study - General and Performance Specifications for Small Urban Transit Bus", National Technical Information Service, PB-269-397, Springfield, VA, December, 1976.

23. RRC International, Inc., "Small Transit Bus Requirements Study - Performance Specifications for Advanced Design", National Technical Information Services, PB-269-398, Springfield, VA, March, 1977.

24. RRC International, Inc., "Small Transit Bus Requirements - Study Guidelines For the Design of Future Small Transit Buses and Bus Stops to Accommodate the Elderly and Handicapped," National Technical Information Service, PB-269-396, Springfield, VA, January, 1977.

25. Ringham, Rodger F. "Executive Summary, SAE/DOT, Truck and Bus Fuel Economy Measurement Program", SAE Paper No.: 831783, Truck and Bus Meeting and Exposition, Cleveland, OH, November, 1983.

26. Rosenbloom, Sandra, "State of the Art in Vehicle Design and Technology", UMTA, U.S. DOT, Washington, D.C., March, 1983.

27. Shaefer, R. H. and D. L. Robinson, "Automatic Transmissions for Passenger Coaches", SAE, Paper No.: 750381, Automotive Engineering Congress and Exposition, Detroit, Mich., February, 1975.

28. Transportation Development Center, "Transit Vehicle for the Disabled", February, 1983.

29. Transportation Research Board, "Rural Public Transportation," Transportation Research Record No. 696, TRB, Washington, D.C., 1978.

30. Transportation Research Board, "Transportation Services for the Handicapped in Urban Areas Conference Proceedings," UMTA, U.S. DOT, Washington, D.C., March, 1983.

31. Transportation System Center, "UMTA Small Transit Vehicle Procurement Workshop Proceedings," UMTA, Office of Bus Technology, Washington, D.C., November, 1984.

32. U.S. Department of Transportation, "Small Transit Vehicles," Stock No.: 050-000-00204-7, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., August, 1981.

33. Varker, Frank, "Small Transit Bus Requirements Study Guidelines for the Design of Future Small Transit Buses," UMTA, U.S. DOT, March, 1977.

34. Wegmann, F. I. et al, "Planning Transportation Services For Handicapped Persons: User's Guide", NCTRP Report #262, Transportation Research Board, Washington, D.C., September, 1983.

35. Weiers, Bruce J., "Small Bus Manufacturing Industry," UMTA, Office of Technical Assistance, Washington, D.C., January, 1985.

ARKANSAS HIGHWAY AND TRANSPORTATION DEPARTMENT

VOLUME II

PLANNING AND SPECIFICATIONS FOR SMALL TRANSIT BUS

by

M. M. Bakr

University of Arkansas at Little Rock
School of Engineering Technology

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16. Abstract
The report covers service planning methodology, bus type selection using tabulated local life-cycle cost data, and detailed bus specifications. The report is intended to be used as planning and bus purchasing guide for operators of small bus fleets used in rural transit and for the transportation of elderly and handicapped persons. Bus specifications cover the majority of bus equipment with influence on safety, performance, maintenance cost, accessability and ride quality.

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SUMMARY OF FINDINGS AND IMPLEMENTATION STATEMENT

Small transit bus acquisition requires projection of transportation needs and establishing plans for iniating a new service, improving current service or expanding the present system. Small buses are used primarily for rural and small area transit, as well as, for special transportation of handicapped persons.

Material covered in this report outlines the service planning procedure for the case of regular, fixed route and schedule, rural and small urban area transit systems, as well as, the specialized door-to-door transportation for handicapped persons. The planning processes have been adopted from previous research and reports which addressed specifically the previous areas. Methodology and data pertinent to the state of Arkansas was used to provide means for service planning and determination of vehicle type. The bus buyer is well advised to assume the role of a local planner and establish the basic vehicle parameters before working out the specifications.

The planning process commonly ends up with the determination of needed vehicle(s). Consideration of fleet reassignment follows and is viewed as means to reduce the maintenance and operating cost of the bus fleet when placing the new buses in service. Alternate plans of vehicle type and capacity are considered at this point. Life cycle cost evaluation is used to determine the most economical alternative.

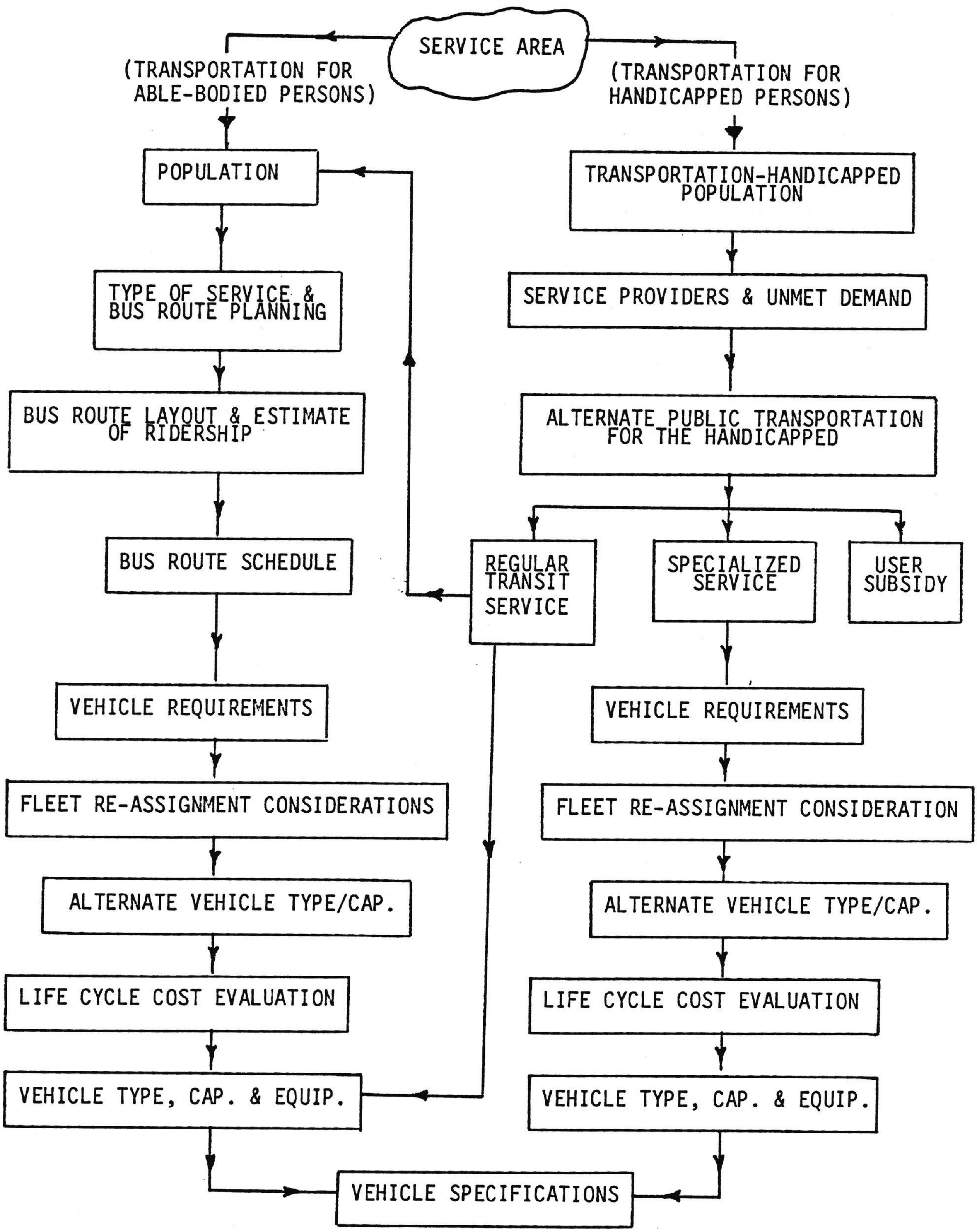
This report is intended to be used as a procedure manual for the service planning, bus type selection and detailed bus specifications. If service planning is not required, the user may skip the service planning sections, pages 4-25. Life cycle cost evaluation identifies the most economic choice of bus type. Tabular data provided in this section is representative of the state of Arkansas. Bus specifications are provided for a range of small buses which can serve 17-24 passengers including handicapped riders.

OVERVIEW OF SERVICE PLANNING AND BUS ACQUISITION PROCESS

Unless the bus is purchased as a direct replacement for an existing unit, or unless the demand for service is clearly defined such as in the case of establishing a contract service for a certain client or a major traffic generator with a defined transportation requirements, it is advisable that an effort be made to follow a stepwise process in determining the demand for service, bus requirements and specifications. The process, outlined in Figure 1, establishes the transportation demand both for able-bodied and transportation handicapped persons, and considers various service alternatives. This is followed by evaluating alternate vehicles based upon projected life cycle cost, and ultimately establishing bus specifications.

Figure 1 outlines the overall process involved in bus acquisition. It consists of two largely separate planning processes; one concerns the acquisition of buses for regular public transit involving mostly fixed route service, and the other concerns the acquisition of buses for the specialized transportation of handicapped persons. The only link between these two processes is that concerning the transportation of handicapped persons who could most conveniently and economically be accommodated by regular public transportation. The existence of such a group in the service area would require considering the transportation of handicapped persons in the planning process of regular transit. Among the important considerations in this respect is equipping buses with means for accommodating the handicapped persons such as wheelchair lifts, grab bars and wheel chair securement devices. The two planning processes mentioned previously are outlined in detail in the following.

Figure 1: Service Planning and Bus Acquisition Process



SERVICE PLANNING AND VEHICLE

REQUIREMENTS FOR ABLE-BODIED PASSENGERS

SERVICE PLANNING AND VEHICLE REQUIREMENTS FOR ABLE-BODIED PASSENGERS[1]

The planning process of regular transit service for able-bodied passengers starts with the survey of the service area, understanding the objectives and role of the transit system and ends up with the determination of alternative vehicle type/capacity to provide the service, Figure 1. It is not necessary that the complete planning process be followed every time new buses are needed to replace aging buses or to expand the service, on the other hand it is important that the basic considerations outlined in the process be updated regularly and be taken into account at times when considering the acquisition of new buses. The process is detailed in the following:

Step 1

Define the area the system must serve, identify the major trip destinations within the area and estimate the population in the area.

Step 2

Establish transit system goals, identify the type of service to be provided; fixed schedule and route, flexible schedule and route, or any combination in-between.

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[1]Adopted from Reference 2: "Small Transit Vehicles: How to Buy, Operate and Maintain," by A. B. Boghani et al., NCTRP Report #11, Transportation Research Board, Washington, D.C., January, 1985.

Step 3

Estimate the number of bus routes needed - roughly one route for 5,000 to 10,000 residents.

Step 4: Bus Route Planning and Layout (Table 1)

First, identify all streets that are suitable for bus traffic. Second, determine from the destination points and the suitable streets whether a grid system (a combination of north-south and east-west routes) or a hub and spoke system (all routes meet and exchange passengers at a central transfer point downtown) will best meet public needs. Third, identify transfer points. Last, consider where the buses can turn around at the end of a line - without having to back up - to return to the point of origin.

Now rough out a preliminary route map. Look for linear routes (those that operate outbound and inbound in the same street) - they are the most productive. As a second choice, select routes that loop through a residential neighborhood at the end of the line (lollipop routes) but travel to and from downtown on the same street. Avoid, where possible, full loop routes - routes that go outbound on one street and inbound on another. This type of route has proven to be the least attractive in generating ridership. Considerations for service and route planning are outlined in Table 1. Summarize route selection.

Step 5: Estimate Ridership Levels (Table 2)

At this point the route system should be fairly well defined and one can begin to estimate the ridership level (number of fares collected). To do this, it is necessary to convert the overall population estimate that was obtained earlier to more specific kinds of people information - ages, income levels, car ownership, and type of housing. Such information can be obtained from census data or from statistics compiled by the city planning department. Enter this information in Form 1 Appendix A.

Next, estimate the number of people who live within convenient walking distance of the route (the catchment area). If socioeconomic status data are available, use Table 2; otherwise measure the population within 1/8 mile on either side of the route. Determine the "catchment factor" as given in Table 2. Enter both catchment area and catchment factor in Form 1, Appendix A. This factor can be used to convert area population to ridership level. Here note that the ridership level is the number of fares collected on an average weekday. It may or may not be equal to the number of people who ride the buses from the population under consideration. In fact, many people will take two rides and thus pay two fares each day. In that case, the ridership level would be two times the number of people riding the bus.

To estimate the average weekday ridership on a system, multiply the population in the catchment area by the catchment factor for the route, as shown in Form 1, Appendix A.

Step 6: Establish Bus Schedule

DETERMINE THE NUMBER OF BUSES REQUIRED FOR THE BUS ROUTE (Table 3).

Next, it is necessary to establish headways (the time in minutes between bus departures) for each route. Headways affect the permissible length of a route and the number of buses needed to operate each route. Use headways that

TABLE 1: SERVICE AND ROUTE-PLANNING GUIDELINES

Factors to Consider	
1. Area to be served	Neighborhood, village township, city county, metropolitan area, state.
2. Major trip destinations	Downtown, shopping centers, medical centers, schools, university, business district, industrial park.
3. Type of service	Fixed schedule/fixed route requires minimum population of 25,000. For smaller populations consider fixed schedule/flexible route. Reserve flexible schedule/flexible route for special circumstances; e.g., for paraplegics, retarded children.
4. Suitability of streets	Proximity to trip destinations. Proximity to population to be serviced -- in fixed route systems boarding points should be within 1/4 mile of dwellings. Street width -- should be wide enough to let two buses pass.
5. Route system type	Hub and spoke; grid; service to any point within a zone.
6. Transfer points	Central terminal, shopping center, downtown intersections.
7. Routes	Bus turnaround areas, service areas coverage, zone boundaries, linear, partial (lollipop) loop, full loop, 2-way streets rather than 1-way.
8. Headways	Even fraction of an hour round-trip time (running time plus layover time) zone cycle time.
9. Route adjustments	Round-trips should equal one headway or even multiple of a headway.

TABLE 2: ESTABLISHING RIDERSHIP LEVELS

Step	Things to Consider
1. Establish Population Characteristics	Age, income levels, car ownership, student population, and type of housing
2. Determine Convenient Walking Distance	500 ft (1/10 mile) if socioeconomic status above average, 700 ft (1/8 mile) if socioeconomic status average, 1000 ft (1/5 mile) if socioeconomic status below average.
3. Estimate Population Within Convenient Walking Distance of the Route (catchment area)	The population characteristics and convenient walking distance.
4. Determine Catchment Factor	<u>Route Type</u> / <u>Catchment Factor</u> Loop: 0.14 - 0.17 Lollipop: 0.20 - 0.23 Linear: 0.22 - 0.24 <u>Use higher number</u> in the range for: low-income residents, multiple-family dwellings, high age level, low car ownership, or students. <u>User lower number</u> in the range for: high income residents, single-family dwellings, low age level, high car ownership.
5. Calculate Average Weekday Ridership (No. of fares collected)	Multiply population in the catchment area by catchment factor for the route.

TABLE 3: STANDARD HEADWAYS WHICH PRODUCE REPEATING TIME TABLES

Headways (minutes)	Buses/Hour
60	1
30	2
20	3
15	4
12	5
10	6
6	10
5	12

are an even fraction of an hour (Table 3) because repeating schedules will be easier for riders to memorize. Headways of 15 min. or less do not increase ridership appreciably, so use such short headways only if passenger loadings require them. As a starting point, a 30-min. headway represents a good balance between the need for frequency and the need to control operating costs.

Adjust the preliminary route map by modifying route lengths as necessary to match headways. Compute the round-trip time for a route by adding the scheduled time (minutes) for: running outbound, end-of-line layover, running inbound, and central terminal layover. A bus, under normal traffic conditions, travels about 15 mph (1/4 mile per minute). To the extent practical, add or subtract mileage and increase or reduce layover time so as to make the round-trip time an even multiple of the standard headway. These adjustments facilitate future scheduling decisions. Enter the headway and timetable information in Form 2, Appendix A. Calculate number of buses required by dividing peak-hour round-trip time by peak-hour headway and rounding off to the next larger integer.

Step 7: ESTIMATE BUS CAPACITY

To determine how large a bus is needed for a system, construct a time table (to establish the number of peak and off-peak trips), compute the number of trips that would be required if each trip carried a peak-hour load (equivalent loads), compute the average number of passengers carried on a peak-hour trip, and set loading standards (the number of people to be carried sitting or standing).

For the time table, list each inbound and outbound trip for each day of the week that service is offered. Use one list for the Monday through Friday schedule, and when appropriate, separate lists for Saturdays, and for Sundays, and Holidays. Since the weekday requirements will be decisive in selecting a bus, use the Monday-Friday time table to identify the number of trips each day during peak hours (8-8:59 a.m., 5-5:59 p.m.), base periods (6-7:59 a.m., 9 a.m.-4:59 p.m.) and evening hours (6 p.m.-midnight). Count only the buses leaving from the originating point of the route. Enter the bus frequency in Form 3, Appendix A.

To compute equivalent loads, assume that most trips will operate loaded in one direction only: inbound in the morning and outbound in the afternoon. Count the number of trips inbound before noon and the number of trips outbound after noon. Assign weights to each trip operating in the loaded direction as follows:

peak hour - 1.0 (W_1)

base period - 0.5 (W_2)

evening - 0.25 (W_3)

These weights reflect the fact that base period trips carry about half the passengers of a peak-hour trip, and evening trips about a quarter of that number. Calculate the equivalent loads for a route from the following relationship: $N_1 \times W_1 + N_2 \times W_2 + N_3 \times W_3 = EL$

<u>where</u>:

N_1, N_2, N_3, = number of trips in the peak direction in the time period (peak, base, or evening);

W_1, W_2, W_3, = weight assigned for the time period (1.0, 0.5, and 0.25, for peak, base and evening); and

EL = equivalent loads for the time period.

Add the equivalent loads for each time period to obtain the total equivalent loads for a route. These calculations can be done in Form 3, Appendix A.

Next, calculate the number of passengers you expect to ride on a single peak-hour trip. Divide the forecast average weekday ridership (which was calculated on Form 1, Appendix A) by the number of equivalent loads scheduled on the route. The resulting figure is the number of passengers forecast to ride a single peak-hour trip in the peak direction, as shown in Form 3, Appendix A.

Step 8: DETERMINE BUS SIZE AND OVERALL SEATING PLAN

The bus which was selected should have a passenger capacity sufficient to accommodate the expected peak hour, peak direction load without crowding. If the type of service to be operated normally accommodates standing passengers, a seating plan must be selected in order to be able to define an acceptable ratio of standing passengers to seated passengers. In general, a 2 and 1 seating plan (two seats on one side of the aisle and one on the other) provides greater flexibility in handling peak-hour demand, without the necessity of scheduling additional buses, while a 2 and 2 seating plan provides a higher percentage of riders with a seat. In a bus with a 2 and 1 seat plan, the total passenger capacity of the bus can be assumed to be about 1.5 times the number of seats installed. Thus, to compute the number of seats required, divide the forecast number of peak direction passengers on a peak-hour trip by 1.5 (in the case of a 2 and 1 seating plan), or by 1.25 (in the case of a 2 and 2 seating plan). These calculations can be done in Form 4, Appendix A.

The length of bus needed to accommodate the forecast peak direction peak-hour passenger load is then estimated from the number of seats required.

Estimate the number of rows of seats needed by dividing the total seats requirement by 3 in the case of a 2 and 1 seating plan, or by 4 in the case of a 2 and 2 seating plan, as shown in Form 4, Appendix A. The overall length in feet of the bus needed can be estimated by multiplying the number of rows of seats by 3 ft. This assumes a seat pitch of 30 in., and considers the space required for the driver and the doors.

For example, if the forecast peak-direction peak-hour passenger load is 45 passengers, and a 2 and 1 seating plan is assumed, a bus with space for 30 seated passengers and 15 standees is required. With 3 seats per row and 30 seats, there will be 10 seat rows. Assuming an overall spacing of 3 ft. per row, the smallest suitable bus would be 30 ft long. Compare the required bus capacity, number of seats, number of rows, and length with those of the buses under consideration. Make an initial selection from this comparison, as shown in Form 5, Appendix A. Test the usefulness of the bus size that has been selected by repeating the calculations in this section for the next less frequent headway, and the next more frequent headway. Adjust bus size or headway, as necessary, to obtain an optimum combination of the two.

Step 9: IDENTIFY LIMITATIONS ON BUS SELECTIONS

Although the buses selected may be the correct size, other considerations may eliminate some. The most important considerations are the following:

- Size limits (height, width, length, turning radius): Will the bus be able to clear overpasses and fit on all bridges? Will it be able to turn corners on all streets or within the dimensions of a terminal? Length and rear overhang (that portion of the body behind the rear wheels) are especially important factors. The longer the rear overhang, the greater the outward movement of the rear of the bus when turning. This makes maneuvering in tight situations difficult. A lane width of twice the bus width could be required for turning a bus with a longer rear overhang in a sharp corner. If there are narrow streets or it is necessary to operate in areas where frequent swerving around parked cars in required, one might want to avoid buses with long rear overhangs.

- Weight limits: Is the bus too heavy for any of the bridges, overpasses, or roads over which it must travel? Is the pavement at bus stops durable? Frequent starts and stops of heavy buses at curbside have been known to destroy some pavements in as few as 50 stops/starts.

This information should be available from the manufacturers of the different buses. Once this step is performed, one will have a final list of candidate buses. Form 5, Appendix A can be revised to exclude the buses which do not meet the above limitations.

SERVICE PLANNING & VEHICLE REQUIREMENTS
FOR TRANSPORTATION HANDICAPPED PERSONS

SERVICE PLANNING & VEHICLE REQUIREMENTS FOR TRANSPORTATION HANDICAPPED PERSONS

Section 16(c) of the Urban Mass Transportation Act of 1964, as amended, defines a transportation handicapped person as: "any individual who by reason of illness, injury, age, congenital malfunction, or other permanent or temporary incapacity or disability, is unable without special facilities or special planning or design to utilize mass transportation facilities as effectively as persons who are not so affected."

The planner needs to know approximately how many handicapped person there are in the community; where these people live; their physical capabilities and limitations; their salient social, economic, and demographic characteristics; the modes of transportation available to them; how often they currently travel; the purpose for which they make trips and the modes of transportation they currently use; their desire for travel; and the external factors that limit their ability or desire to travel.

Transportation planning for handicapped persons begins with the estimation of the handicapped population and determination of their travel needs. It takes into account various modes available for satisfying these needs. This includes fixed route and schedule bus service, specialized door-to-door services and user-side subsidies. The demand for the specialized door-to-door service can be determined on the basis of the total need and the available services. The number of vehicles needed to provide the specialized door-to-door service can be determined on the basis of vehicle productivity which

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[1] Adopted from Reference 1: "Planning Transportation Services for Handicapped Persons - User's Guide," by F. J. Wegmann et al., NCHRP Report #262, Transportation Research Board, Washington, D.C., 1983.

is influenced by the operating rules used in the system. Vehicle size is influenced the peak load and the need for special equipment on the vehicle.

The following outlines the steps necessary to determine the number of buses required for the specialized door-to-door service. The steps describe the process by which the number of buses can be determined. It requires the use of the local data cited above. On the other hand, in the absence of local data, selected representative and synthesized data, developed as a guide for planning, can be used for the same purpose.[1]

STEP 1: ESTIMATE TRANSPORTATION HANDICAPPED POPULATION

The average estimate of transportation handicapped persons for the south central states including the state of Arkansas is 6.1% of the total population. Local data would provide a better estimate of this value.

Focusing attention on the segment of the population to be considered in transportation planning (age 5 and older), this segment represents 92.8% of the total population.

Hence, in the absence of local data, the estimate of the local handicapped population = (Local Population) x (0.928) x (0.061)

The handicapped population can further be subdivided for transportation planning purpose into:

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[1] Reference 1

(a) Slightly Handicapped; which are persons who have a little more difficulty using public transportation than persons who are not handicapped;

(b) Moderately Handicapped; which are persons who can use public transportation, but only with a lot more difficulty than persons who are not handicapped;

(c) Severely Handicapped; which are person who have extreme difficulty using public transportation or who cannot use public transportation at all.

The number of handicapped persons in the various above categories can be determined by local survey or by use of reference data.[1]

STEP 2: ESTIMATE THE TRAVEL DEMAND FOR THE TRANSPORTATION HANDICAPPED POPULATION

Rate of trip generation for the various segments of the handicapped population (slightly, moderately and severely handicapped) is dependent on automobile availability.

Automobile availability will result in approximately 50% increase in the rate of trip generation.

Estimate the number of projected daily trips (one way trips) for the various segments of the handicapped population based upon the rate of trip generation. In the absence of local data, average rates of trip generation are available[2].

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[1] Reference 2, Table 2, Pg. 6.

[2] Reference 2, Table 5, pg. 7.

Current modal split between automobile, regular transit, specialized door-to-door service and taxi-cab can be determined based on local data. Selected national data on modal split[1] may be used as a guide when local data is not available.

The number of trips devoted to various purpose (medical, recreational, etc.) can also be established based upon local data on trip purpose. Selected national data on trip purpose for transportation handicapped persons is also available[2].

STEP 3: SERVICE PROVIDERS AND UNMET DEMAND

A provider inventory can be approached as an estimation procedure to define the extent and magnitude of resources being devoted to handicapped mobility needs.

Unmet needs will be reflected by gaps and shortfalls existing in the provision of handicapped transportation services. Specification information should be obtained on the nature of the unmet needs such as: (1) services are not being provided to a particular client group; (2) hours of travel that do not overlap with service hours; or (3) trip demands extending beyond the service area. Unmet needs then help set priorities for refining existing services or establishing additional services.

Subtracting private vehicle driver and private vehicle passenger trips from total trips determines the number of trips that should be made by bus,

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[1] Reference 2, Table 6, pg. 7.

[2] Reference 2, Table 7, pg. 8.

taxi, specialized service, and other means. Aggregate transportation handicapped ridership data collected from the provider inventory yield an approximate estimate of the number of these trips that are actually accounted for. The residual trips (i.e., total trips less private vehicle trips and those identified in the provider inventory) yield a rough estimate of the potential number of unmet trip needs.

STEP 4: DEMAND FOR ALTERNATIVE TRANSPORTATION SERVICES

Several general approaches to solving the transportation problems of transportation handicapped people are avilable. The more common approaches include the following:

- Fixed route and schedule transit services made accessible to handicapped people.
- Special, fully accessible, specialized transportation services.
- Individual subsidies to transportation handicapped persons to help them pay for transportation services such as taxis.
- Various combinations of the foregoing approaches.

In considering the various service options, the planner should be cognizant of the specific attributes of each service option as well as the characteristics of the different market segments[1].

Estimate of expected demand due to initiating or expanding one of the above services consist of the following:

(a) Current trips, or trips that were already being made via the transportation service.

[1] Reference 2, pg. 12.

(b) New trips, or trips that were not made by any mode of transportation before the transportation solution was implemented.

(c) Diverted trips, or previously made trips that were diverted to the new or improved transportation service from other modes.

The total trips to be taken on a transportation service for transportation handicapped people are the sum of the current trips, the new trips (i.e., latent demand), and the diverted trips.

Estimate of current trips can be obtained from trip inventory data collected by the service agency or from the value of the estimate obtained in Step 2.

Estimate of new trips that are made when initiating or expanding an existing service can be obtained by direct survey of the transportation handicapped population or of a sample of the same population. Approximate values can be obtained from available derived data[1].

Estimate of diverted trips that will take place when iniating or expanding and existing service can also be obtained by direct survey of the transportation handicapped population or of a sample of the same population. Approximate values can be obtained from available derived data[2].

STEP 5: ESTIMATE OF VEHICLE REQUIREMENTS

Estimate of vehicle requirements is based upon the provision of specialized door-to-door service. Other options such as the use of regular fixed

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1 Reference 2, Table 11, pg. 14.

2 Reference 2, Table 12, pg. 14.

route and schedules transit would require equipping a certain portion of the transit bus fleet with means to accommodate wheelchair passengers. The additional demand to serve the transportation handicapped persons can be added to the regular travel demand and the total can be used as a basis for service planning.

Number and bus capacity to provide specialized service for the transportation handicapped persons can be derived according to the following:

(a) Estimate the hourly distribution of trips made by handicapped persons during the day. Number of trips made in the various time segments of the day can be determined using the local data. In the absence of local data, representative data can be used to provide an approximate estimate[1].

(b) Estimate the vehicle productivity in person trips/vehicle-hour based upon local conditions. Selected, representative data are also available [2].

(c) Estimate the number of vehicles needed at various time segments of the day by dividing the number of person trips per hour for various time segments by vehicle productivity in person-trips per hour. Maximum number of vehicle would provide an estimate of the required number of vehicles.

(d) Once operational fleet size is determined, adequate fleet reserves must be provided. A suggested fleet reserve policy is as follows:

- Up to 7 vehicles in fleet, add 1 vehicle.

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[1] Reference 2, Table 34, pg. 27.

[2] Reference 2, Table 33, pg. 27.

- 8 to 20 vehicles in fleet, add 2 vehicles.
- 20+ vehicles in fleet, add 1 vehicle for every 10.

(e) Although vehicle capacity is a factor in determining vehicle productivity, and high productivity values are expected to be associated with larger capacity vehicles, nevertheless, other travel demand factors, such as the degree of concentration of the transportation handicapped population, the commonalty of destination and the degree of uniformity of trip purpose will increase the productivity of larger vehicles.

Vehicle type and capacity may be considered at this point. The advantage of additional flexibility of smaller vehicles versus the economy expected of the larger vehicles depends upon a number of local attributes and the service organization, as well as, other factors such as the service area, travel patterns, and convenience of use.

CONSIDERATION OF FLEET RE-ASSIGNMENT AND LIFE CYCLE COST EVALUATION

CONSIDERATIONS OF FLEET RE-ASSIGNMENT

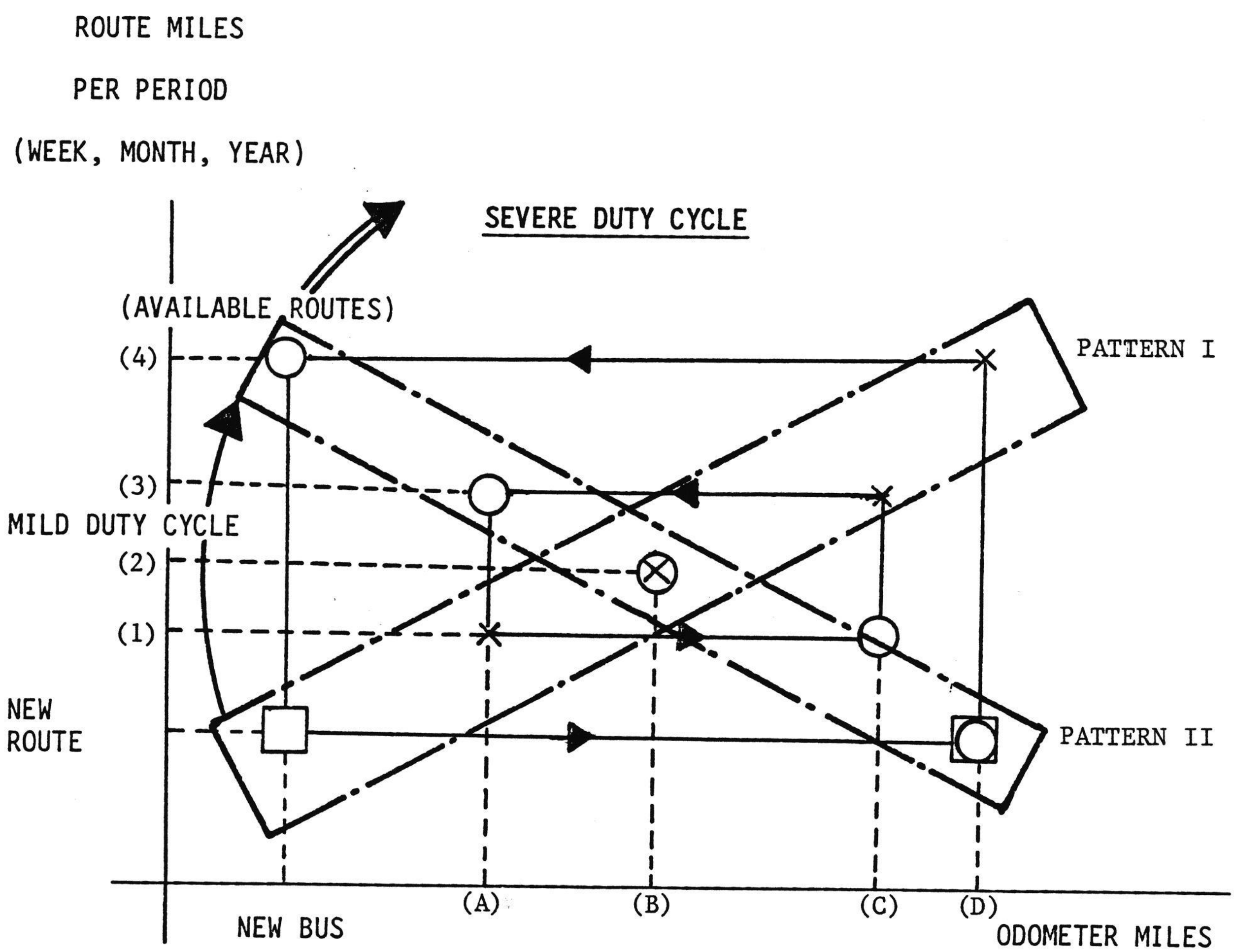
The previous steps have been used to determine the bus capacity and size parameters. At this point it is feasible to consider the possibility of filling the need by assigning an existing bus to the route under consideration and replacing the reassigned bus by a new one with the purpose of achieving lower overall maintenance and operating cost.

It is important at this stage that a review of current fleet condition and assignment be undertaken. This explores the opportunity of fleet re-assignment with the objective of reducing the overall maintenance and operating cost. The potential for cost improvement comes from the fact that maintenance cost and repair incidents increase as the bus ages. The result is that old buses assigned to long routes with short headway, which accumulate considerable miles per year, would incur higher maintenance cost per mile resulting in higher total maintenance and operating cost and lower reliability for the bus fleet as a whole. Acquisition of new buses allows the opportunity of assigning newer buses (buses with low odometer miles) to more severe service, and high mile routes, while older buses (buses with high odometer miles) are assigned to moderate and mild service, and low mile routes. The reassignment process is performed among equivalent buses, that is buses that have the same capacity and general features. This includes bus type consideration to assure that cost differential due to bus type and severity of service has been taken into account.

Figure 2 shows a simple manual approach for fleet reassignment. The approach involves plotting annual route miles against bus odometer miles, for

FIGURE 2: BUS-ROUTE REASSIGNMENT

°THE PURPOSE IS TO MOVE TOWARD PATTERN II
°SEVERITY OF SERVICE REQUIRES A STEEPER PATTERN OF ROUTE MILES AGAINST ODOMETER MILES.



X - CURRENT ASSIGNMENT

O - PROPOSED REASSIGNMENT

☐ - NEW BUS - INITIAL ROUTE ASSIGNMENT

▣ - NEW BUS - FINAL ROUTE ASSIGNMENT

PATTERN I: CURRENT

PATTERN II: AFTER REASSIGNMENT

equivalent buses. The relationship trend is examined, and bus reassignment is performed to achieve a more desirable pattern shown in Figure 2.

ALTERNATE BUS CHOICE

A list of bus types, number and size of each type which would be required to satisfy projected transportation needs will now be available. Organize these options into the summary Form 6, Appendix A. The following steps involve evaluating the life cycle cost of each of the above alternatives and the selection of the bus type which is best suited for the application on hand.

LIFE CYCLE COST EVALUATION

Life cycle cost evaluation methodology and basic data have been developed in a study of small transit vehicles[1]. The procedure and data outlined in the report has been established from a national perspective which takes into account various regions of the country with wide ranging climate and service requirements. The method requires the collection of various data and the use of an elaborate set of calculation. The procedure has been simplified in this manual and converted to the use of a simple set of tables which were developed using data that pertains to the state of Arkansas.

Life cycle cost is the cost of owning, operating and maintaining the bus over the full life of the bus starting at the time of purchase and ending at the time of bus retirement or resale. The cost is averaged over the total life mileage of the bus, and thus is stated in the form of cents per mile over the bus life. The major components of the life cycle cost consist of: (1) capital costs, that is the cost of owning the bus; (2) maintenance cost; (3) fuel cost; and (4) bus operator's cost. Details of the estimation procedure and assumptions made in estimating the previous costs are outlined in the following.

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1 "Small Transit Vehicles: How to Buy, Operate and Maintain," by A. B. Boghani et al., NCHRP Report #11, Transportation Research Board, Washington,, D.C., January, 1985.

CAPITAL COST (Table 1)

$$\text{Capital Cost/Mile} = \frac{\text{Purchase Cost of The Bus - Salvage Value}}{\text{Bus Life in Miles}}$$

where: Purchase Cost of The Bus is given in Table (8) Appendix (B)

Salvage Value: 15% of the purchase cost (After 10 years life span)

Bus Life in Miles: is given in Table (8), Appendix (B) and is modified to limit the useful bus life to 10 years. Survey of a sample of bus operators in Arkansas showed a wide range of annual bus mile (less than 6000 to over 30,000 miles per year). A limit of 10 years useful life of the bus was used in computing the capital cost per mile to account for obsolescence due to potential major shift in requirements.

MAINTENANCE COST (Table 2)

The following factors determine the maintenance component of the life cycle cost for the state of Arkansas: (1) Type of Bus, (2) Severity of Service, (3) Bus Miles per Year, (4) Shop Rate for Maintenance Work. A phone survey established maintenance shop rate in the range of $10-25 per hour. Data concerning labor, parts usage and mileage factor for maintenance of various types of buses are included in Tables (8)and (9), pages 9 and 10 of Reference 2. Inflation rate for the price of spare parts and for shop rate was established at 5% per year.

FUEL COST (Table 3)

$$\text{Fuel Cost/Mile} = \frac{\text{Fuel Cost/Gal.}}{\text{Fuel Consumption in Miles/Gal.}}$$

where: Fuel cost ranges from 0.80 - 1.25 Dollars per Gallon according to a survey of Sections 16(b)(2) and 18 operators.

Fuel consumption for various types of buses is given in Table 9, Appendix B.

DRIVER COST (Table 4)

The following factors determines the driver's component of the life cycle cost:

(1) Driver's pay rate in Dollars per hour. Phone survey established the rate to be in the range of 3.40 - 5.70 $/Hr.

(2) Driver's productivity in miles travel per hour. This value has a wide range of variation between one agency and the other. 10 - 36 miles per hour was established as the likely range considering Sections 16(b)(2) and 18 operators.

Life Cycle Cost =
(Cents Per Mile)

Capital Cost (Table 4) +

Maintenance Cost (Table 5) +

Fuel Cost (Table 6) +

Driver's Cost (Table 7)

TABLE 4
CAPITAL COST PER MILE
BASED ON 1984 AVERAGE BUS COST
¢/MILE

MILES/YR	VAN MODIFIED VAN	BODY ON VAN CHASSIS	BODY ON TRUCK CHASSIS	PURPOSE BUILT
6000	14.2	35.4	49.6	127.5
8000	10.6	26.6	37.2	95.6
10000	8.5	21.2	29.7	76.5
12000	8.5	21.2	24.8	63.7
14000	8.5	21.2	21.2	54.6
16000	8.5	21.2	18.6	47.8
18000	8.5	21.2	17.0	42.5
20000	8.5	21.2	17.0	38.2
22000	8.5	21.2	17.0	34.8
24000	8.5	21.2	17.0	31.9
26000	8.5	21.2	17.0	29.4
28000	8.5	21.2	17.0	27.3
30000	8.5	21.2	17.0	25.5

TO OBTAIN AVERAGE COST FOR YOUR YEAR OF PURCHASE, MULTIPLY THE ABOVE COST BY THE INFLATION MULTIPLIER SHOWN BELOW:

PURCHASE YEAR	INFLATION MULTIPLIER
1985	1.05
1986	1.10
1987	1.16
1988	1.21
1989	1.28
1990	1.34
1991	1.41
1992	1.48
1993	1.55
1994	1.63
1995	1.71

TABLE 5

MAINTENANCE COST PER MILE ¢/MILE BY CURRENT LABOR RATE $/HR

LABOR RATE $/HR	MILES PER YEAR	VAN MODIFIED VAN MILD	VAN MODIFIED VAN MODERATE	VAN MODIFIED VAN SEVERE	BODY ON VAN CHASSIS MILD	BODY ON VAN CHASSIS MODERATE	BODY ON VAN CHASSIS SEVERE	BODY ON TRUCK CHASSIS MILD	BODY ON TRUCK CHASSIS MODERATE	BODY ON TRUCK CHASSIS SEVERE	PURPOSE BUILT MILD	PURPOSE BUILT MODERATE	PURPOSE BUILT SEVERE
$10	6000	4.5	5.4	6.6	13.6	15.9	18.7	19.6	23.4	27.9	7.6	10.7	15.2
	8000	4.5	5.4	6.6	14.6	17.0	20.1	20.3	24.2	28.9	7.7	10.8	15.4
	10000	4.5	5.4	6.4	15.5	18.0	21.2	20.8	25.0	29.7	7.7	10.9	15.5
	12000	4.2	5.2	6.2	14.8	17.2	20.2	20.5	24.6	29.2	7.8	10.9	15.6
	14000	4.0	5.1	6.0	14.2	16.6	19.5	20.4	24.3	28.9	7.8	10.9	15.6
	16000	4.0	4.9	5.9	13.9	16.1	19.1	20.3	24.2	28.6	7.8	11.0	15.7
	18000	3.9	4.8	5.7	13.6	15.9	18.7	20.0	23.9	28.3	7.8	11.0	15.8
	20000	3.9	4.8	5.7	13.5	15.6	18.5	19.6	23.3	27.6	7.8	11.0	15.8
	22000	3.8	4.7	5.6	13.3	15.5	18.2	19.1	22.8	27.0	7.9	11.1	15.8
	24000	3.8	4.7	5.6	13.1	15.3	18.1	18.8	22.5	26.6	7.9	11.1	15.9
	26000	3.7	4.6	5.6	13.1	15.2	17.9	18.5	22.1	26.2	8.0	11.2	16.0
	28000	3.7	4.6	5.4	12.9	15.0	17.6	18.3	21.8	25.8	8.0	11.2	16.1
	30000	3.7	4.6	5.4	12.9	15.0	17.6	18.1	21.6	25.6	8.0	11.3	16.2
$12	6000	5.0	6.2	7.5	15.0	17.5	20.8	21.9	26.3	31.5	8.5	11.8	16.6
	8000	5.0	6.2	7.5	16.0	18.8	22.3	22.7	27.2	32.6	8.5	11.9	16.8
	10000	5.0	6.2	7.4	17.0	19.8	23.5	23.3	28.1	33.5	8.6	12.0	17.0
	12000	4.8	5.9	7.1	16.2	18.9	22.4	22.9	27.6	32.9	8.6	12.0	17.0
	14000	4.6	5.7	6.9	15.6	18.3	21.6	22.7	27.3	32.5	8.6	12.0	17.1
	16000	4.5	5.6	6.7	15.3	17.8	21.1	22.5	27.0	32.2	8.7	12.1	17.1
	18000	4.4	5.5	6.5	14.9	17.5	20.7	22.3	26.7	31.8	8.6	12.1	17.2
	20000	4.4	5.4	6.5	14.8	17.2	20.5	21.8	26.0	31.0	8.6	12.1	17.2
	22000	4.3	5.4	6.4	14.5	17.0	20.2	21.3	25.5	30.4	8.7	12.2	17.3
	24000	4.2	5.3	6.4	14.4	16.9	20.0	20.9	25.1	29.9	8.7	12.2	17.4
	26000	4.2	5.2	6.3	14.3	16.7	19.8	20.6	24.7	29.5	8.8	12.3	17.5
	28000	4.2	5.2	6.2	14.1	16.6	19.5	20.3	24.3	29.0	8.8	12.3	17.5
	30000	4.2	5.2	6.2	14.1	16.5	19.6	20.1	24.1	28.8	8.8	12.4	17.6

TABLE 5 (cont)

MAINTENANCE COST
PER MILE
¢/MILE
BY CURRENT LABOR RATE $/HR

LABOR RATE $/HR	MILES PER YEAR	VAN MODIFIED VAN MILD	VAN MODIFIED VAN MODERATE	VAN MODIFIED VAN SEVERE	BODY ON VAN CHASSIS MILD	BODY ON VAN CHASSIS MODERATE	BODY ON VAN CHASSIS SEVERE	BODY ON TRUCK CHASSIS MILD	BODY ON TRUCK CHASSIS MODERATE	BODY ON TRUCK CHASSIS SEVERE	PURPOSE BUILT MILD	PURPOSE BUILT MODERATE	PURPOSE BUILT SEVERE
$14	6000	5.6	6.9	8.4	16.3	19.2	22.9	24.2	29.2	35.0	9.3	12.8	18.1
	8000	5.6	6.9	8.4	17.4	20.5	24.4	25.1	30.2	36.3	9.3	13.0	18.3
	10000	5.6	6.9	8.3	18.5	21.6	25.8	25.8	31.2	37.4	9.4	13.1	18.5
	12000	5.3	6.6	8.0	17.6	20.7	24.6	25.3	30.6	36.7	9.4	13.1	18.5
	14000	5.1	6.4	7.7	17.0	19.9	23.8	25.0	30.2	36.2	9.4	13.1	18.5
	16000	5.0	6.2	7.6	16.6	19.4	23.2	24.8	29.9	35.8	9.5	13.2	18.6
	18000	5.0	6.1	7.4	16.2	19.1	22.7	24.5	29.5	35.3	9.5	13.2	18.6
	20000	4.9	6.1	7.3	16.0	18.8	22.5	24.0	28.8	34.5	9.5	13.2	18.6
	22000	4.8	6.0	7.2	15.8	18.6	22.1	23.4	28.1	33.7	9.5	13.3	18.7
	24000	4.7	6.0	7.2	15.6	18.5	22.0	23.0	27.8	33.2	9.5	13.3	18.8
	26000	4.7	5.8	7.1	15.6	18.3	21.7	22.7	27.3	32.7	9.6	13.4	18.9
	28000	4.7	5.8	7.0	15.3	18.1	21.4	22.4	26.9	32.2	9.6	13.4	19.0
	30000	4.7	5.8	6.9	15.4	18.0	21.5	22.2	26.7	31.9	9.6	13.5	19.1
$16	6000	6.2	7.6	9.3	17.7	20.9	24.9	26.5	32.0	38.6	10.1	13.9	19.5
	8000	6.2	7.6	9.3	18.9	22.3	26.6	27.5	33.2	40.1	10.2	14.1	19.7
	10000	6.2	7.6	9.2	19.9	23.5	28.1	28.3	34.3	41.3	10.2	14.2	18.8
	12000	5.9	7.3	8.9	19.0	22.5	26.8	27.7	33.6	40.4	10.3	14.2	19.9
	14000	5.6	7.1	8.5	18.3	21.6	25.9	27.4	33.1	39.8	10.2	14.2	20.0
	16000	5.5	6.9	8.4	17.9	21.1	25.2	27.1	32.8	39.3	10.3	14.2	20.0
	18000	5.5	6.8	8.2	17.5	20.7	24.7	26.8	32.4	38.8	10.3	14.3	20.1
	20000	5.4	6.7	8.1	17.3	20.4	24.5	26.2	31.5	37.9	10.3	14.3	20.1
	22000	5.3	6.6	8.0	17.1	20.2	24.1	25.6	30.8	37.1	10.4	14.4	20.1
	24000	5.2	6.6	7.9	16.9	20.0	23.9	25.1	30.4	36.5	10.4	14.4	20.2
	26000	5.2	6.4	7.9	16.8	19.8	23.7	24.8	29.9	36.0	10.4	14.5	20.3
	28000	5.2	6.4	7.7	16.6	19.6	23.3	24.4	29.5	35.4	10.4	14.4	20.4
	30000	5.1	6.4	7.7	16.6	19.6	23.4	24.2	29.3	35.1	10.4	14.5	20.5

TABLE 5 (cont)

MAINTENANCE COST
PER MILE
¢/MILE
BY CURRENT LABOR RATE $/HR

LABOR RATE $/HR	MILES PER YEAR	VAN MODIFIED VAN MILD	VAN MODIFIED VAN MODERATE	VAN MODIFIED VAN SEVERE	BODY ON VAN CHASSIS MILD	BODY ON VAN CHASSIS MODERATE	BODY ON VAN CHASSIS SEVERE	BODY ON TRUCK CHASSIS MILD	BODY ON TRUCK CHASSIS MODERATE	BODY ON TRUCK CHASSIS SEVERE	PURPOSE BUILT MILD	PURPOSE BUILT MODERATE	PURPOSE BUILT SEVERE
$18	6000	6.8	8.4	10.2	19.0	22.5	27.0	28.8	34.9	42.2	10.9	15.0	21.0
	8000	6.8	8.4	10.2	20.3	24.0	28.8	29.9	36.2	43.8	11.0	15.2	21.2
	10000	6.7	8.3	10.1	21.4	25.3	30.4	30.8	37.4	45.1	11.1	15.3	21.4
	12000	6.4	8.0	9.7	20.5	24.2	29.0	30.1	36.6	44.2	11.1	15.3	21.4
	14000	6.2	7.8	9.4	19.7	23.3	28.0	29.7	36.0	43.4	11.1	15.3	21.4
	16000	6.1	7.5	9.2	19.3	22.7	27.3	29.4	35.6	42.9	11.1	15.3	21.5
	18000	6.0	7.4	9.0	18.9	22.4	26.7	29.0	35.2	42.3	11.1	15.4	21.5
	20000	5.9	7.3	8.9	18.6	22.0	26.5	28.4	34.3	41.3	11.1	15.4	21.5
	22000	5.8	7.3	8.8	18.3	21.8	26.1	27.7	33.5	40.4	11.2	15.5	21.6
	24000	5.7	7.2	8.7	18.2	21.6	25.9	27.3	33.1	39.8	11.2	15.5	21.6
	26000	5.7	7.1	8.7	18.1	21.4	25.6	26.9	32.5	39.2	11.3	15.5	21.7
	28000	5.6	7.0	8.5	17.8	21.2	25.2	26.5	32.1	38.6	11.3	15.5	21.8
	30000	5.6	7.0	8.5	17.8	21.1	25.3	26.3	31.8	38.3	11.3	15.6	21.9
$20	6000	7.3	9.1	11.1	20.4	24.2	29.1	31.1	37.8	45.7	11.8	16.1	22.4
	8000	7.3	9.1	11.1	21.7	25.8	31.0	32.3	39.2	47.5	11.8	16.3	22.6
	10000	7.3	9.1	11.0	22.9	27.1	32.6	33.3	40.6	49.0	11.9	16.4	22.9
	12000	7.0	8.7	10.6	21.9	26.0	31.2	32.5	39.6	47.9	12.0	16.4	22.9
	14000	6.7	8.4	10.2	21.1	25.0	30.1	32.1	39.0	47.1	11.9	16.4	22.9
	16000	6.6	8.2	10.0	20.6	24.4	29.3	31.7	38.5	46.5	12.0	16.4	22.9
	18000	6.5	8.1	9.8	20.2	24.0	28.8	31.3	38.0	45.8	11.9	16.5	23.0
	20000	6.4	8.0	9.7	19.9	23.6	28.4	30.6	37.0	44.7	11.9	16.5	22.9
	22000	6.2	7.9	9.6	19.6	23.3	28.0	29.9	36.2	43.8	12.0	16.6	23.0
	24000	6.2	7.8	9.5	19.4	23.2	27.8	29.4	35.7	43.1	12.0	16.5	23.1
	26000	6.2	7.7	9.4	19.3	22.9	27.5	29.0	35.1	42.5	12.1	16.6	23.2
	28000	6.1	7.6	9.3	19.0	22.7	27.1	28.5	34.6	41.8	12.1	16.6	23.2
	30000	6.1	7.6	9.2	19.1	22.6	27.2	28.3	34.4	41.5	12.1	16.7	23.3

TABLE 5 (cont)

MAINTENANCE COST
PER MILE
¢/MILE
BY CURRENT LABOR RATE $/HR

LABOR RATE $/HR	MILES PER YEAR	VAN MODIFIED VAN MILD	VAN MODIFIED VAN MODERATE	VAN MODIFIED VAN SEVERE	BODY ON VAN CHASSIS MILD	BODY ON VAN CHASSIS MODERATE	BODY ON VAN CHASSIS SEVERE	BODY ON TRUCK CHASSIS MILD	BODY ON TRUCK CHASSIS MODERATE	BODY ON TRUCK CHASSIS SEVERE	PURPOSE BUILT MILD	PURPOSE BUILT MODERATE	PURPOSE BUILT SEVERE
$22	6000	7.9	9.8	12.0	21.7	25.9	31.2	33.4	40.6	49.3	12.6	17.2	23.8
	8000	7.9	9.8	12.0	23.1	27.6	33.2	34.7	42.2	51.2	12.7	17.4	24.1
	10000	7.9	9.8	11.9	24.4	29.0	34.9	35.8	43.7	52.9	12.8	17.6	24.3
	12000	7.5	9.4	11.5	23.3	27.7	33.4	34.9	42.6	51.6	12.8	17.6	24.3
	14000	7.2	9.1	11.1	22.4	26.7	32.2	34.4	41.9	50.7	12.7	17.5	24.3
	16000	7.1	8.8	10.9	21.9	26.0	31.4	34.0	41.4	50.0	12.8	17.5	24.3
	18000	7.0	8.7	10.6	21.5	25.6	30.8	33.5	40.8	49.3	12.8	17.6	24.4
	20000	6.9	8.6	10.5	21.2	25.2	30.4	32.8	39.8	48.1	12.7	17.6	24.4
	22000	6.7	8.5	10.4	20.9	24.9	30.0	32.0	38.9	47.1	12.8	17.6	24.4
	24000	6.7	8.5	10.3	20.7	24.7	29.8	31.5	38.4	46.4	12.8	17.6	24.5
	26000	6.6	8.3	10.2	20.6	24.5	29.4	31.0	37.8	45.7	12.9	17.7	24.6
	28000	6.6	8.3	10.0	20.3	24.2	29.0	30.6	37.2	45.0	12.9	17.7	24.7
	30000	6.6	8.2	10.0	20.3	24.2	29.1	30.3	36.9	44.6	12.9	17.8	24.8
$24	6000	8.5	10.6	12.9	23.1	27.5	33.3	35.7	43.5	52.8	13.4	18.3	25.3
	8000	8.5	10.6	12.9	24.5	29.3	35.4	37.1	45.2	55.0	13.5	18.6	25.6
	10000	8.5	10.5	12.8	25.9	30.8	37.2	38.2	46.8	56.8	13.6	18.7	25.8
	12000	8.1	10.0	12.3	24.7	29.5	35.6	37.3	45.6	55.4	13.6	18.7	25.8
	14000	7.8	9.8	11.9	23.8	28.4	34.3	36.7	44.8	54.3	13.6	18.6	25.7
	16000	7.6	9.5	11.7	23.3	27.7	33.4	36.3	44.2	53.6	13.6	18.6	25.8
	18000	7.5	9.4	11.4	22.8	27.2	32.8	35.8	43.6	52.8	13.6	18.7	25.8
	20000	7.4	9.2	11.3	22.5	26.8	32.4	35.0	42.6	51.6	13.6	18.7	25.8
	22000	7.2	9.2	11.1	22.2	26.5	31.9	34.2	41.6	50.4	13.6	18.7	25.9
	24000	7.2	9.1	11.1	22.0	26.3	31.7	33.6	41.0	49.7	13.6	18.7	25.9
	26000	7.1	8.9	11.0	21.8	26.0	31.4	33.1	40.4	49.0	13.7	18.8	26.0
	28000	7.1	8.9	10.8	21.5	25.7	30.9	32.6	39.8	48.2	13.7	18.8	26.1
	30000	7.1	8.8	10.8	21.5	25.7	31.0	32.4	39.5	47.8	13.7	18.9	26.2

TABLE 6

FUEL COST
¢/MILE

FUEL COST PER GAL.	VAN MOD. VAN	BODY ON VAN	BODY ON TRUCK GAS	BODY ON TRUCK DIESEL	PURPOSE BUILT GAS	PURPOSE BUILT DIESEL
$0.80	9.0	12.3	15.7	9.3	22.2	13.1
$0.81	9.1	12.5	15.9	9.4	22.5	13.3
$0.82	9.2	12.6	16.1	9.5	22.8	13.4
$0.83	9.3	12.8	16.3	9.7	23.1	13.6
$0.84	9.4	12.9	16.5	9.8	23.3	13.8
$0.85	9.6	13.1	16.7	9.9	23.6	13.9
$0.86	9.7	13.2	16.9	10.0	23.9	14.1
$0.87	9.8	13.4	17.1	10.1	24.2	14.3
$0.88	9.9	13.5	17.3	10.2	24.4	14.4
$0.89	10.0	13.7	17.5	10.3	24.7	14.6
$0.90	10.1	13.8	17.6	10.5	25.0	14.8
$0.91	10.2	14.0	17.8	10.6	25.3	14.9
$0.92	10.3	14.2	18.0	10.7	25.6	15.1
$0.93	10.4	14.3	18.2	10.8	25.8	15.2
$0.94	10.6	14.5	18.4	10.9	26.1	15.4
$0.95	10.7	14.6	18.6	11.0	26.4	15.6
$0.96	10.8	14.8	18.8	11.2	26.7	15.7
$0.97	10.9	14.9	19.0	11.3	26.9	15.9
$0.98	11.0	15.1	19.2	11.4	27.2	16.1
$0.99	11.1	15.2	19.4	11.5	27.5	16.2
$1.00	11.2	15.4	19.6	11.6	27.8	16.4
$1.01	11.3	15.5	19.8	11.7	28.1	16.6
$1.02	11.5	15.7	20.0	11.9	28.3	16.7
$1.03	11.6	15.8	20.2	12.0	28.6	16.9
$1.04	11.7	16.0	20.4	12.1	28.9	17.0
$1.05	11.8	16.2	20.6	12.2	29.2	17.2
$1.06	11.9	16.3	20.8	12.3	29.4	17.4
$1.07	12.0	16.5	21.0	12.4	29.7	17.5
$1.08	12.1	16.6	21.2	12.6	30.0	17.7
$1.09	12.2	16.8	21.4	12.7	30.3	17.9
$1.10	12.4	16.9	21.6	12.8	30.6	18.0
$1.11	12.5	17.1	21.8	12.9	30.8	18.2
$1.12	12.6	17.2	22.0	13.0	31.1	18.4
$1.13	12.7	17.4	22.2	13.1	31.4	18.5
$1.14	12.8	17.5	22.4	13.3	31.7	18.7
$1.15	12.9	17.7	22.5	13.4	31.9	18.9
$1.16	13.0	17.8	22.7	13.5	32.2	19.0
$1.17	13.1	18.0	22.9	13.6	32.5	19.2
$1.18	13.3	18.2	23.1	13.7	32.8	19.3
$1.19	13.4	18.3	23.3	13.8	33.1	19.5
$1.20	13.5	18.5	23.5	14.0	33.3	19.7
$1.21	13.6	18.6	23.7	14.1	33.6	19.8
$1.22	13.7	18.8	23.9	14.2	33.9	20.0
$1.23	13.8	18.9	24.1	14.3	34.2	20.2
$1.24	13.9	19.1	24.3	14.4	34.4	20.3
$1.25	14.0	19.2	24.5	14.5	34.7	20.5

TABLE 7

DRIVER
COST PER MILE
¢/MILE

LABOR RATE/HR	10 MPH	12 MPH	14 MPH	16 MPH	18 MPH	20 MPH	22 MPH	24 MPH	26 MPH	28 MPH	30 MPH	32 MPH	34 MPH	36 MPH
3.40	34.0	28.3	24.3	21.2	18.9	17.0	15.5	14.2	13.1	12.1	11.3	10.6	10.0	9.4
3.45	34.5	28.7	24.6	21.6	19.2	17.2	15.7	14.4	13.3	12.3	11.5	10.8	10.1	9.6
3.50	35.0	29.2	25.0	21.9	19.4	17.5	15.9	14.6	13.5	12.5	11.7	10.9	10.3	9.7
3.55	35.5	29.6	25.4	22.2	19.7	17.7	16.1	14.8	13.7	12.7	11.8	11.1	10.4	9.9
3.60	36.0	30.0	25.7	22.5	20.0	18.0	16.4	15.0	13.8	12.9	12.0	11.2	10.6	10.0
3.65	36.5	30.4	26.1	22.8	20.3	18.2	16.6	15.2	14.0	13.0	12.2	11.4	10.7	10.1
3.70	37.0	30.8	26.4	23.1	20.6	18.5	16.8	15.4	14.2	13.2	12.3	11.6	10.9	10.3
3.75	37.5	31.3	26.8	23.4	20.8	18.8	17.0	15.6	14.4	13.4	12.5	11.7	11.0	10.4
3.80	38.0	31.7	27.1	23.7	21.1	19.0	17.3	15.8	14.6	13.6	12.7	11.9	11.2	10.6
3.85	38.5	32.1	27.5	24.1	21.4	19.2	17.5	16.0	14.8	13.7	12.8	12.0	11.3	10.7
3.90	39.0	32.5	27.9	24.4	21.7	19.5	17.7	16.2	15.0	13.9	13.0	12.2	11.5	10.8
3.95	39.5	32.9	28.2	24.7	21.9	19.7	18.0	16.5	15.2	14.1	13.2	12.3	11.6	11.0
4.00	40.0	33.3	28.6	25.0	22.2	20.0	18.2	16.7	15.4	14.3	13.3	12.5	11.8	11.1
4.05	40.5	33.7	28.9	25.3	22.5	20.2	18.4	16.9	15.6	14.5	13.5	12.7	11.9	11.2
4.10	41.0	34.2	29.3	25.6	22.8	20.5	18.6	17.1	15.8	14.6	13.7	12.8	12.1	11.4
4.15	41.5	34.6	29.6	25.9	23.1	20.7	18.9	17.3	16.0	14.8	13.8	13.0	12.2	11.5
4.20	42.0	35.0	30.0	26.2	23.3	21.0	19.1	17.5	16.2	15.0	14.0	13.1	12.4	11.7
4.25	42.5	35.4	30.4	26.6	23.6	21.2	19.3	17.7	16.3	15.2	14.2	13.3	12.5	11.8
4.30	43.0	35.8	30.7	26.9	23.9	21.5	19.5	17.9	16.5	15.4	14.3	13.4	12.6	11.9
4.35	43.5	36.2	31.1	27.2	24.2	21.7	19.8	18.1	16.7	15.5	14.5	13.6	12.8	12.1
4.40	44.0	36.7	31.4	27.5	24.4	22.0	20.0	18.3	16.9	15.7	14.7	13.7	12.9	12.2
4.45	44.5	37.1	31.8	27.8	24.7	22.2	20.2	18.5	17.1	15.9	14.8	13.9	13.1	12.4
4.50	45.0	37.5	32.1	28.1	25.0	22.5	20.5	18.8	17.3	16.1	15.0	14.1	13.2	12.5
4.55	45.5	37.9	32.5	28.4	25.3	22.7	20.7	19.0	17.5	16.2	15.2	14.2	13.4	12.6
4.60	46.0	38.3	32.9	28.7	25.6	23.0	20.9	19.2	17.7	16.4	15.3	14.4	13.5	12.8
4.65	46.5	38.7	33.2	29.1	25.8	23.2	21.1	19.4	17.9	16.6	15.5	14.5	13.7	12.9
4.70	47.0	39.2	33.6	29.4	26.1	23.5	21.4	19.6	18.1	16.8	15.7	14.7	13.8	13.1
4.75	47.5	39.6	33.9	29.7	26.4	23.7	21.6	19.8	18.3	17.0	15.8	14.8	14.0	13.2
4.80	48.0	40.0	34.3	30.0	26.7	24.0	21.8	20.0	18.5	17.1	16.0	15.0	14.1	13.3
4.85	48.5	40.4	34.6	30.3	26.9	24.2	22.0	20.2	18.7	17.3	16.2	15.2	14.3	13.5
4.90	49.0	40.8	35.0	30.6	27.2	24.5	22.3	20.4	18.8	17.5	16.3	15.3	14.4	13.6
4.95	49.5	41.2	35.4	30.9	27.5	24.7	22.5	20.6	19.0	17.7	16.5	15.5	14.6	13.7
5.00	50.0	41.7	35.7	31.3	27.8	25.0	22.7	20.8	19.2	17.9	16.7	15.6	14.7	13.9
5.05	50.5	42.1	36.1	31.6	28.1	25.2	23.0	21.0	19.4	18.0	16.8	15.8	14.9	14.0
5.10	51.0	42.5	36.4	31.9	28.3	25.5	23.2	21.2	19.6	18.2	17.0	15.9	15.0	14.2
5.15	51.5	42.9	36.8	32.2	28.6	25.7	23.4	21.5	19.8	18.4	17.2	16.1	15.1	14.3
5.20	52.0	43.3	37.1	32.5	28.9	26.0	23.6	21.7	20.0	18.6	17.3	16.2	15.3	14.4
5.25	52.5	43.8	37.5	32.8	29.2	26.2	23.9	21.9	20.2	18.8	17.5	16.4	15.4	14.6
5.30	53.0	44.2	37.9	33.1	29.4	26.5	24.1	22.1	20.4	18.9	17.7	16.6	15.6	14.7
5.35	53.5	44.6	38.2	33.4	29.7	26.7	24.3	22.3	20.6	19.1	17.8	16.7	15.7	14.9
5.40	54.0	45.0	38.6	33.7	30.0	27.0	24.5	22.5	20.8	19.3	18.0	16.9	15.9	15.0
5.45	54.5	45.4	38.9	34.1	30.3	27.2	24.8	22.7	21.0	19.5	18.2	17.0	16.0	15.1
5.50	55.0	45.8	39.3	34.4	30.6	27.5	25.0	22.9	21.2	19.6	18.3	17.2	16.2	15.3
5.55	55.5	46.2	39.6	34.7	30.8	27.7	25.2	23.1	21.3	19.8	18.5	17.3	16.3	15.4
5.60	56.0	46.7	40.0	35.0	31.1	28.0	25.5	23.3	21.5	20.0	18.7	17.5	16.5	15.6
5.65	56.5	47.1	40.4	35.3	31.4	28.2	25.7	23.5	21.7	20.2	18.8	17.7	16.6	15.7
5.70	57.0	47.5	40.7	35.6	31.7	28.5	25.9	23.7	21.9	20.4	19.0	17.8	16.8	15.8
5.75	57.5	47.9	41.1	35.9	31.9	28.7	26.1	24.0	22.1	20.5	19.2	18.0	16.9	16.0

BUS SPECIFICATIONS

BODY STRUCTURE

- Body shall represent an integral structure consisting of skeleton and skin. Body structure shall be properly integrated with the chassis frame (See Body Structure: Attachment to Chassis).
- Structural members shall be permanently joined, thus avoiding the use of screw fasteners and pull type (pop) rivets.
- Body structure shall be able to withstand the static and dynamic forces encountered in normal bus operation showing limited deflection.
- Body shall be free of stress failures and fatigue cracks under normal operation during the expected life of the bus.
- Body shall be able to meet the crush allowance requirements according to FMVSS 220.

BODY STRUCTURE:
FLOOR

- Body floor is the part of the body in contact with the chassis frame. The floor structure serves as the base part of the body to which the upper body structure is attached. It also serves to integrate the body structure with the chassis.
- Body floor shall be made of rigid panels which are securely assembled together and sealed to provide a unified structure. Floor material shall be corrosion resistant.

BODY STRUCTURE:

EXTERIOR SIDE AND ROOF PANELS

- All exterior side and roof panels shall have the minimum physical properties of 20 gauge steel. Panels shall be sufficiently stiff and property supported to prevent vibration, drumming or flexing while bus is in normal operation. Panels shall be made of rust resistant material or be given rust treatment on both sides.
- Panels shall be buck rivited, bonded or welded to the body frame. When panels are lapped sealant shall be applied in the lap joint to prevent the entrance of moisture and dirt.
- All screw type fasteners shall be of the lock type and shall not shake loose due to vibration or deflection. Rivets and fasteners shall be cadmium plated to protect against corrosion.
- The use of pull-type (pop) rivets shall be avoided.

BODY STRUCTURE:

STEPWELL

- Stepwell shall be made as an integrated structure, securely attached to bus body and body frame.
- Stepwell shall be capable of supporting 250 pounds without showing noticeable signs of deflection.
- Stepwell material and joints shall be properly treated against corrosion.

BODY STRUCTURE:
BODY ATTACHMENT TO CHASSIS

. Bus body shall be securely attached to the chassis frame so that the entire assembly behaves as a single unit without a detectable movement at the joint.

. Resilient material used in isolating the body from the chassis shall not be subject to aging, fatigue failure or failure due to extreme temperatures and moisture.

. Resilient material used in isolating the body from the chassis shall be incorporated in the design in such a manner that its failure would not constitute a hazard that would, over a period of time, result in a structural failure.

BODY STRUCTURE:
FRONT AND REAR BUMPERS

. Bumpers shall protrude and wrap around the body to protect the body corners, and be bolted directly to the vehicle frame.

. Bumpers shall be made of one piece, heavy duty steel, steel reinforced aluminum or approved equal.

. Bumpers shall be chrome plated, black or white painted, or anodized aluminum.

BODY INTERIOR:
INSULATION

. Inside walls, ceiling and firewall shall be insulated with a minimum of

1-1/2 in. fiberglass bats or an equivalent material with the same insulation value.

- Insulation shall be fire and mildew resistant and compatible with the wiring and hose surface material in contact with the insulation.

BODY INTERIOR:

FLOOR LINING

- Floor lining is the layer of material sandwitched between the structural floor which is integrated in the body structure and the floor covering.
- Floor lining shall be made of a minimum 5/8 in. exterior plywood, grade BC with butt formed joints. All edges, cut-outs and notches shall be properly sealed after cutting to prevent moisture from entering the plywood layers.
- Joints of any two adjacent layers of the floor shall not coincide.
- Floor lining must be securely attached to the structural floor.

BODY INTERIOR:

FLOOR COVERING

- Aisles, entrance and exit platform areas, driver's platform, entrance and exit steps shall be covered with at least 3/16 inch ribbed, non-skid, transit type vinyl or rubber (RCA Rubber) floor covering, or approved equal.
- Underseat and wheel housing areas shall be covered with minimum 1/8 inch smooth, anti-skid, vinyl or rubber of the same material quality as above, or approved equal.

. Floor covering shall be butt jointed with no lip or nosing overhang, and be bonded properly to the floor lining.

. Metal stripping or molding shall cover all floor covering joints between ribbed, aisle, entrance and exit platform areas, and the smooth underseat areas. Molding shall also be applied at the junction of the floor covering with the side wall panels and the wheel housing covering.

. Color of the floor shall contrast with the seat color so as to be easily distinguished by visually impaired persons.

. A standee line shall be at least 2 in. wide, across the bus aisle in line with the rear pillar of the front door, or as required by local law.

. All steps shall have at least one inch wide band of bright contrasting color running the full width of the leading edge.

BODY INTERIOR:

INSIDE LINING

. Inside lining shall have the minimum physical properties of 24 gauge steel and shall be covered with a scuff resistant easy to clean material.

. Inside lining and trim shall be designed and constructed to avoid protrusions and sharp corners.

. Inside lining color shall be harmonized with seat and floor cover colors.

. All interior material shall be flame retardent and shall meet FMVSS 571-302.

. Rivets and fasteners used in assembling the inside lining shall have a color that blends with the panel color.

BUS INTERIOR:

INTERIOR DIMENSIONS

. Interior Height at the Center Aisle (Minimum)	74 in.
. Interior Height at 6 inches from the sidewalls (Minimum)	67 in.
. Interior Width (Minimum)	90 in.
. Aisle Width (Minimum)	18 in.
. Ground to first step (Maximum)	11 in.
. Additional steps rise (Maximum)	9 in.
. Tread Depth (Minimum)	9 in.

BUS INTERIOR:

FLOOR PLANS

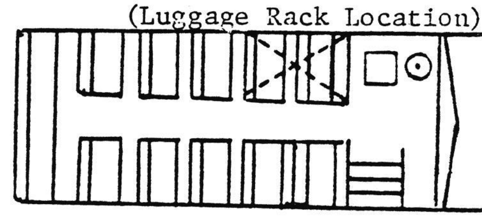
The floor plan shall meet the nature of the service and the needs of the ridership. Bus interior can be planned to accommodate seated passengers, standing passengers, space for carry on luggage and groceries and even space for stretcher patients.

An initial determination must be made as to the specific requirements of the bus and to the desired degree of flexibility; an example is the case of a bus which would be required to carry a peak load of 18 seated and 4 standees. At a frequency of three times a week it is necessary to accommodate a wheelchair passenger at the expense of the regular passenger space. This bus would be planned with a fixed seat space, standee space and convertible seat space that can be changed to accommodate wheelchair passengers when the need arises.

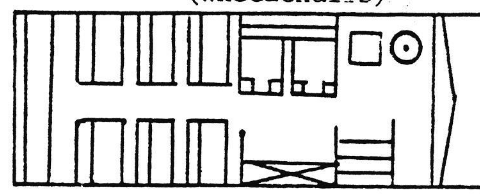
Figure 3 shows examples of typical bus floor plans and the advantages of each. This can be used as a guide for the selection of a suitable bus floor plan.

FIGURE 3: BUS FLOOR PLANS

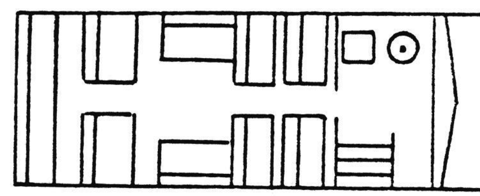
Plan 1: 2 and 2 seating plan. High capacity, suitable for longer trips and older age commuters.



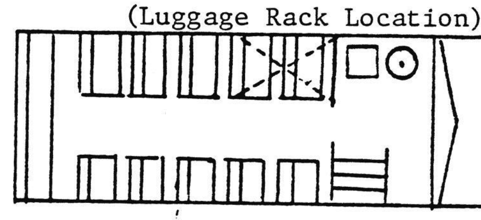
Plan 2: 2 and 2 seating plan with accomodations for two wheelchairs.



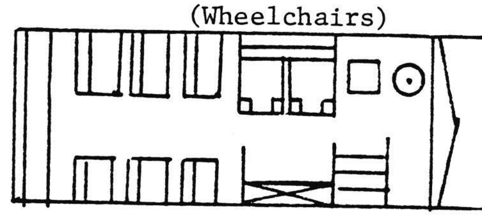
Plan 3: 2 and 2 seating plan. Seats over wheel housing are turned sideways. Plan accomodates more standees than Plan 1. Suitable for a mix of short and long trips.



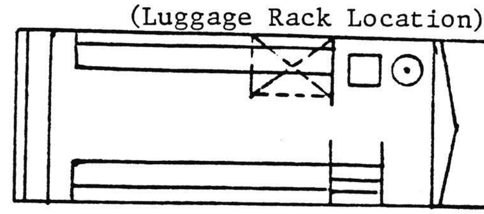
Plan 4: 2 and 1 seating plan. Plan provides more space for standees and can accomodate a greater ratio of short trip commuters.



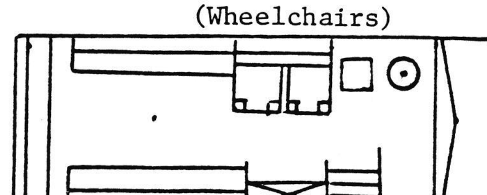
Plan 5: 2 and 1 seating plan with accomodations for two wheelchairs.



Plan 6: 1 and 1 seating plan. Plan provides maximum space for standees, and can accomodate the largest ratio of short trip commuters.



Plan 7: 1 and 1 seating plan with accomodations for two wheelchairs.



BUS INTERIOR:
PASSENGER SEATS (FIXED)

- Seat space is such that knee to hip room is 27 in. minimum. Seat width is 18 in. minimum per passenger. Seat cushion is (17.5 - 18.00 inch) above floor.
- Seat is transportation quality, properly cushioned for body support. Seat shall have a padded arm rest at the aisle side.
- Seat back shall be fully padded with 1 inch minimum of energy absorbing material on the back and top side. Seat shall have a padded grab handle at the top aisle side corner.
- Seat frame shall be properly constructed and seat leg(s) shall be contoured and positioned to minimize interference with passengers' movement around the seat area.
- The underside of the seat shall be enclosed to prevent debris accumulation.
- Seat shall be covered with transportation grade, perforated, flame resistant vinyl. The color shall be coordinated with the rest of the bus interior.

BUS INTERIOR:
PASSENGER SEATS (FOLDING)

Wall mounted, folding bench seats shall be used in the space designated for wheelchairs. When in the folded position the seat cushion shall be locked in place and will allow the wheelchairs to be secured in place with properly mounted locks.

BUS INTERIOR:

SAFETY RAILS & STANCHIONS

- Vertical stanchions shall be provided at the entrance way, driver's area and exit way to provide support for standing and moving passengers.
- Left and right grab rails shall be installed at the stairwell entrance to be used in assisting passengers who are entering the bus.
- Ceiling rail at left and right of the center aisle shall be provided to assist standees and passengers who are moving in the aisle.
- Stanchions and grab bars shall not interfere with the normal flow of regular and wheelchair passengers.
- Grab bars are 1-1/8 inch diameter, material is of sufficient strength to withstand the forces caused by passengers holding the bars during bus motion. Material (aluminum or stainless steel) must be finished for proper gripping and ease of cleaning.
- Stanchions and grab bars shall be mounted to the body frame.
- Properly cushioned modesty panels shall be provided for the two front seats and the seat behind the chair lift entrance.

DRIVER COMPARTMENT:

GAUGES & DISPLAYS

- Instrument panel shall be designed to provide a coordinated, easy to learn, display by function. Red warning lights for various functions shall be associated with the gauge display of the same function. The instrument cluster shall be within the normal vision field of the bus driver with no sight obstruction. Displays shall be properly labeled for ease of identification.

Following gauges and displays shall be provided on the instrument panel:

FUNCTION	ANALOG DISPLAY	WARNING LIGHT (condition)	ALARM (condition)
Engine Temperature	X	X (Hot)	X (Hot)
Current charge/discharge	X	X (Discharge)	
Oil Pressure	X	X (Low)	X (Low)
Air Pressure	X	X (Low)	X (Low)
Fuel level	X		
Gen./Alt. not charging		X	
Emergency Exit		X (Unlocked)	X (Unlocked)
Directional Signal		X	
Headlight - High Beam		X	
Parking Brake		X (Engaged)	
Primary Brake System		X (Failure)	
Speedometer/odometer	X		

(Air conditioning displays are listed separately under air conditioning)

. Visible reverse operation warning shall conform to SAE standard J593. Audible reverse operation warning shall conform to SAE Recommended Practice J994, Type C.

DRIVER COMPARTMENT:

CONTROLS

Controls shall be clustered by function and placed within the reach of the bus driver. Toggle switches are preferred for two-status controls and multi-position rotary switch are preferred for multi-status switches. Controls shall be grouped by function and be properly coded/labeled.

The following controls shall be provided, optional controls may also be required by the purchasing agency:

CONTROL FUNCTION	REQUIRED	OPTIONAL
1. Windshield Wiper	X	
2. Windshield Washer	X	
3. Passenger Area Light	X	
4. Driver/Entrance Lights	X	
5. Passenger Signal to Driver		X
6. Head & Taillights	X	
7. Head lights - High Beam	X	
8. Clearance and Marker Lights	X	
9. Destination Sign Lights		X
10. Destination Sign Motor		X
11. Front Heater Temperature	X	
12. Front Heater/Defroster Blower	X	
13. Rear Heater Temperature	X	
14. Rear Heater Blower	X	

(Air conditioning controls are listed separately under air conditioning)

DRIVER COMPARTMENT:

MIRRORS & GLARE PROTECTION

- Two flat exterior rear view mirrors at least 6 in. x 9 in. shall be mounted within the driver visual range to the right and left of the bus.
- Two convex exterior rear view mirrors at least 3 in. diameter shall be mounted within the driver's visual range to the right and left of the bus.
- Inside rear view mirror shall be located above the windshield. Mirror shall be large enough to provide full view of bus interior.

. Adjustable sun visor that can be stored away shall be provided for the driver. Visor shall be acrylic or polycarbonate material of glazing quality coated to resist scratching and shall allow maximum visible light transmittance of 10 percent.

. Mirrors shall be firmly supported and adjustable.

. Mirrors and mountings shall be free of sharp points or edges that could contribute to pedesterian injury (FMVSS111).

. A 10 in. x 8 in. Vangard wide angle vision lens shall be mounted in the right rear window of the bus.

DRIVER COMPARTMENT:

DRIVER'S SEAT

. Transportation quality, properly cushioned and contoured for body and back support.

. Seat shall be forward - backward and height adjustable.

. Seat shall be covered with transportation grade, heavy duty, perforated, flame resistant vinyl.

. Seat shall be equipped with a retractable seat belt anchored to the seat frame.

CLIMATE CONTROL:
HEATER

- Bus shall be equipped with two separate heater units - one in the front and the other in the passenger compartment.
- Front Unit:
  - Hot water type
  - Capacity 25,000 BTU
  - Unit has separate temperature control
  - Unit has blower with a minimum of two speeds
  - Air flow is 400 c.f.m.
  - Unit is used for heating the front area of the bus including the entrance and driver's area, and for defrosting the windshield, sidewindows and door.
- Rear Unit:
  - Hot water type
  - Capacity 40,000 BTU
  - Unit has separate temperature control
  - Unit has blower with a minimum of two speeds
  - Air discharge is 600 c.f.m.

CLIMATE CONTROL:
AIR CONDITIONING

- Heavy duty unit, min. capacity of 45,000 BTU
- Two evaporator units one for the driver and front of the bus, and the second is for the passenger compartment.

- Evaporator units shall be equipped with a minimum of two speed blowers.
- Corner ducts running the length of the bus with directionally controlled outlets shall be used for air distribution.
- Evaporator in the passenger compartment shall be mounted to the body structural numbers using appropriate bracing to assure proper weight distribution on the body frame. All fasteners shall be of the locking type.
- Evaporator in the passenger compartment shall be equipped with two drain hoses front and back for mid-bus mounted units, and right and left end for rear mounted units to provide proper drainage regardless of the angle of inclination of the bus.
- Refrigerant hoses, electrical wiring shall be properly bundled and routed to avoid contact with moving parts in the suspension and drive train, and with the exhaust system. The wire and hose bundle shall be secured adequately at intervals not exceeding 24 in. to the chassis frame.
- Refrigerant hoses, electrical wiring and drain hoses shall be properly routed in the passenger compartment and shall be shielded from occasional contact with passengers or baggage.
- Connection of refrigerant hoses shall be made using screw style hose end clamps according to SAE J516 or equivalent.
- All air conditioning controls shall be grouped and installed within easy reach of the driver.
- Air conditioning refrigerant circuit shall be equipped with a high and low pressure cut-off relay and a driver warning system.

- Air conditioning systems with engine driven compressor shall be equipped with an idle speed booster to increase the engine speed when air conditioning is turned on, vehicle transmission in neutral and engine is at idle speed.
- A special air induction system shall be provided for skirt mounted engines to minimize dust particles flow from under the bus.
- A special, self-cleaning, dust removal system shall be installed on the cooling-air flow for the condenser on skirt mounted units.

DOORS

- Small buses shall be equipped, as a standard feature, with a front passenger entrance/exit door. The door is placed across from the driver's position. An additional exit door located towards the middle or rear of the bus is optional when deemed feasible. A driver door on left side of the bus may also be required.
- Passenger door shall have the minimum clear opening of 24 in. wide and 72 in. high.
- Passenger door shall be outward folding panels, or two outward opening leafs.
- Passenger front door shall be manually operated by the driver using a heavy duty swing arm, or as an option by a heavy duty power operated opener using a conveniently mounted switch. Power operated openers shall have a convenient manual back-up system in the case of malfunction.

- All elements of the door activator system shall be free from trouble and reliable to operate.
- Soft rubber seal shall be incorporated in the door perimeter to prevent draft and dust from entering the bus. The vertical leading edge(s) of the door shall consist of a soft rubber cushion.
- Door shall have safety glass panels which allow the driver to see directly outside the vehicles in the passenger boarding area.
- All hinged and moving surfaces of the door shall be designed and constructed to avoid causing injury to passengers.
- Bus shall have a lock system which allows the bus to be locked for security purposes and be key opened from the outside.

WINDOWS:
WINDSHIELD

- Windshield shall be made of tinted, tempered or laminated safety glass with maximum light transmission of 70%. The upper portion of the windshield shall have a dark shade band unless adequately shaded by a front roof overhang. The band shall have no more than 5 percent transmissivity of visible, infrared and ultraviolet light.

WINDOWS:
PASSENGER WINDOWS

- Passenger windows shall be designed to be openable to allow for ventilation throughout the bus.

- Windows shall be made of laminated, tinted glass with maximum light transmission of 28% or of approved equal.
- Movable window panel shall be designed to remain in adjusted open position when bus is in operation. Window shall be equipped with a latch on the inside.
- Windows shall meet FMVSS 205.

EMERGENCY EXITS:
SIDE WINDOWS

- Bus shall be equipped with at least two emergency exit windows, one on each side of the bus.
- Emergency exit windows shall be placed close to the center of the bus and be clearly labeled.
- Emergency exit windows shall conform to FMVSS 217.

EMERGENCY EXITS:
REAR EXIT DOOR OR REAR WINDOW

- Bus shall be equipped with a rear exit window or a rear exit door.
- Rear window shall have the same glass specification as the regular passenger windows.
- Rear window shall be hinged at the top and be of a push out type design.
- Rear emergency door shall be outward opening, secured by mechanism which can be opened from inside or outside. Outside opening feature may be locked from inside.

- Rear emergency exit door mechanism shall be easy to operate at the same time could not be accidentally opened under normal circumstances.

PAINT, TRIM AND UNDERCOATING

- Body parts shall be given a thorough anti-rust treatment before painting.
- Paint shall be of Dupont Emron or approved substitute.
- Body shall have at least one rub rail or a wide piece of trim minimum 1/2 in. thick running the full length of the bus on both sides. Height of the rail shall be at least 24 in. above ground.
- Buses equipped for handling wheelchair passengers shall have two International symbols of accessibility, one by the lift and the other at the rear of the bus.
- Logo and name of the agency (specified by the buying agency) shall be painted on an accent strip.
- All underbody and fender wells shall be coated with anti-corrosion and sealing material. Material shall be non-flammable, resin type polyoleum, Ziebart, Quaker State Loundoff or approved equal.
- Rear wheel wells shall be equipped with mud flaps.

BUS CHASSIS:
DIMENSIONS, RATINGS & CAPACITIES

- Chassis shall have a minimum wheel base of 125 inches.
- Maximum rear overhang shall not exceed 50% of the wheel base.

- Front axle rating (Min.) 3900 lbs.
- Rear axle rating (Min.) 7000 lbs.
- GVWR (Min.) 10,000 lbs.
- Front tires shall be singles 8.75 x 16.5.
- Rear tires shall be doubles 8.75 x 16.5.
- Spare tire shall be mounted under the bus in such a manner that it will be easily accessible, and will not reduce the road clearance.
- Front and rear tires shall be tubless, steel belted radials, minimum 8 ply rated tread, Load Range D and all weather type.
- Fuel tank capacity shall be 35 Gallons.

BUS CHASSIS:
SUSPENSION, STEERING AND BRAKES

- Suspension shall be equipped with heavy duty springs or air bags.
- Suspension shall include heavy duty shock absorbers 1-3/8 inch diameter min.
- Suspension shall be equipped with front and rear stabilizer bars.
- Steering shall be heavy duty, power assisted.
- Steering wheel shall be of the tilt type of 16-20 inch diameter.
- Service brakes shall be power assisted, hydraulic or air with a fail safe system, a driver's warning light and an audible alarm indicating primary system failure and loss of braking power. Wheel brake lining shall be self adjusting for wear.
- Front brakes shall be of the disc type, 12.5 inch disc rotor and 45 sq. in. minimum lining area.

- Rear brake shall be disc or drum, heavy duty, 13 in. x 3.5 in. minimum, lining area of 160 sq. in. per set of wheels.
- Emergency brake shall be heavy duty, mechanical type, foot or hand operated and capable of stopping the vehicle within 50 feet at 20 m.p.h.

BUS CHASSIS:

ENGINE & DRIVE TRAIN

- Engine shall have the following requirements

16-20 Passenger	350 CID Gasoline
20-24 Passenger	427 CID Gasoline

- Heavy duty diesel engine with equivalent horsepower, properly matched transmission and rear axle is optional.
- Cooling system shall be heavy duty, with extra cooling capacity radiator, heavy duty water pump, thermostat and other components.
- Radiator fan shall be thermostatically controlled and radiator shall be equipped with a coolant recovery system.
- Exhaust system shall have heavy duty, corrosion resistant muffler and exhaust piping. Tail pipe shall terminate at the left rear corner of the body and shall be directed away from the curb.
- Transmission shall be heavy duty, three speed, automatic with external transmission fluid cooler.
- Bus components shall be easily accessible and access doors shall be provided when necessary to facilitate the service and replacement of the bus component. This include: engine, transmission, radiator, batteries, air conditioning system and fuel sender unit.

ELECTRICAL SYSTEM:

BATTERIES

- Two heavy duty, deep cycling 12 volts batteries 160 minute reserve capacity. 500 amps cold cranking capacity. (200 amp. hr. rating)

ELECTRICAL SYSTEM:

CHARGING SYSTEM

- Charging system shall be heavy duty, 100-150 amps depending on bus options and accessories.
- Charging system shall have sufficient output at idle speed to balance current draw requirements including lights and climate control system.
- Alternator shall have a dual belt drive and an external voltage regulator.

ELECTRICAL SYSTEM:

WIRING

- Wiring shall be heavy duty, color coded, automotive type wiring. Wire shall be bundled in a split case type harness for easy access.
- Wiring shall have bulk head disconnect and automotive type connections. Connections must be moisture proof or be sealed in moisture proof enclosures.
- Bus body wiring harness shall be accessible for trouble shooting and repairs.

- Electrical system must have an accessible main power disconnect switch. The switch shall be capable of interrupting the total circuit load without causing damage to any of the electrical components when power plant is in operation.
- Electrical system must be grounded to the frame, body and engine with proper grounding wires.
- All circuits shall be protected by an automatic, manual-reset circuit breakers, or line fuses. Circuit breakers and fuses are to be placed in a properly labeled fuse box; and shall be easily identifiable when placed at discrete locations.

ELECTRICAL SYSTEM:
INTERIOR LIGHTING

- Overhead and stepwell light shall not be less than 12 ft. candle.
- Shielded stepwell light shall be mounted to provide light on each step tread plus an area on the ground three feet beyond the lower step.
- Passenger compartment dome light shall be sufficient for a reading level at the seated passenger height.
- Instrument panel shall be indirectly lighted and equipped with a dimmer switch.
- An outside area light shall be provided for the night operation of the wheelchair lift or ramp if the bus is so equipped.

ELECTRICAL SYSTEM:

EXTERIOR LIGHTING

- Must comply with Federal Motor Vehicle Safety Standards - and requirements of the state of Arkansas. (Federal Motor Carrier Safety Regulations 393.12)
- Bus shall be equipped with sealed headlights, front, rear directional signals, and side turning light to illuminate the area next to the bus in a turning situation.
- Bus shall be equipped with two clear back-up lights, stop and tail lights, license lights, front and rear clearance lights, front and rear identification markers lights.

WHEELCHAIR LIFT OR RAMP

Vehicles outfitted to handle wheelchair passengers are eqipped with wheelchair lifts or ramps, the necessary space to maneuver a wheelchair on board and the means to secure the wheelchair in place aboard the vehicle. The choice between wheelchair lift and ramp is based upon the type of service, frequency of use and the street space available for operating the lift or the ramp. The cost of a lift is multiple fold that of a ramp, the same is true with the cost of maintenance. Wheelchair lift is more convenient to use and easy to operate, causes less vehicle delay and requires limited space at the curb side of the vehicle. A ramp on the other hand is less expensive, requires little or no maintenance. Ramps fold and require little stow away space in the vehicle, however, they require more space to operate on the street (3 ft by

10-15 ft) than a lift. Ramps are commonly extended from the rear door. They are therefore preferred for use in narrow streets with narrow or no curbs. The use of a ramp may also require the assistance of the driver.

The above factors must be weighted carefully before deciding on the type of device to be used.

WHEELCHAIR LIFT

- The lift shall be electro-hydraulic or electro-mechanical, semi-automatic type design. Operation to include power up, manual fold. Platform shall be counter balanced and shall require the strength of an average person to fold and unfold. Lift shall not require an auxiliary power source.
- Platform shall be stowed securely in a vertical position, and shall be designed to cause no noise or vibration during the normal operation of the vehicle.
- Platform surface shall be non-skid expandable metal type which allows a see through for objects under the lift when the lift is operated from inside the vehicle.
- Platform useful area shall be 30 in. x 42 in. with a two, 2 inch side edges. Lift platform shall include safety locking wheel barrier that performs a smooth entry ramp onto the lift and locks automatically after wheelchair entry.
- Wheelchair lift frame overhead-cross-member shall be higher than the door opening, and door opening height shall be a minimum of 67 inches. Cross-member shall be padded to avoid injury to passenger.

- Lift capacity shall be 750 lbs. minimum.
- In the case of primary system malfunction, the lift shall have a manual safety override, for complete lift operation. The manual device shall be designed for driver's ease of operation, safety and approximate normal operating time.
- A skid resistant bridge plate shall provide for the movement of wheelchair from platform to the bus. Area connecting the bridge plate to the aisle area shall also be skid resistant.
- Safety sensor switch on the bridge plate shall prevent the movement of the platform when wheelchair or passenger is on the bridge plate.
- Platform shall have horizontal grab rail to assist passengers when raising and lowering the platform. Grab rail shall fold and stow away with the platform.
- Platform operating speed shall be uniform with controlled deceleration and stop.
- Lift shall be equipped with an interlock device to prevent operation of the lift when the lift door is not open.
- Controls to be conveniently located on a flexible cut resistant cable for easy operation inside or outside the vehicle.
- Control mounting brackets shall be provided on the inside and outside of the vehicle to provide for temporary securement of the control during lift operation.
- Control shall be of the type requiring continuous operator's pressure to control platform movement.
- Vehicle transmission and brake system shall be interlocked with wheelchair lift to prevent movement of the bus during lift operation.

WHEELCHAIR RAMP

- Ramp shall be constructed of light weight material and be easy to deploy and stow away.
- Ramp shall provide a grade of 1:12 for entering or leaving the vehicle.
- Ramp shall be made of non-skid type material and shall be at least 36 in. in width.
- Ramp shall be made to withstand a total weight of 900 lbs.
- Ramp shall not rattle or vibrate when stowed away during the normal operation of the vehicle.

SAFETY AND EMERGENCY EQUIPMENT

- Vehicle shall be equipped with front and rear tow hooks.
- Jacking plates or equivalent shall be provided on the underframe of the vehicle.
- Vehicle shall be equipped with an emergency four-way flasher.
- Vehicle shall also be equiped with the following emergency equipment:
  1. One fire extinguisher approved by Underwriters Laboratory with a minimum classification of 2-A:10-B:C meeting USDOT standards. This shall be a dry pressure extinguisher equipped with a metal valve assembly sealed in such a manner that the seal will not interfere with the operation of the extinguisher.
  2. Three emergency triangle flares conforming with USDOT standards.
  3. One first-aid kit. This shall be a minimum 16 unit kit.

APPENDIX A: BASE DATA FOR LIFE CYCLE COST CALCULATION

Table 8: Average Bus Cost and Expected Life in Miles

Bus Type	Average Cost ($)	Maximum Life Estimate (Miles)
1. Van and Modified Van	10,000	100,000
2. Body on Van Chassis	25,000	100,000
3. Body on Truck Chassis	35,000	175,000
4. Purpose Built	90,000	1,000,000

Table 9: Small Bus Fuel Consumption (Miles Per Gallon)[1]

Bus Type	Fuel Type	Average MPG
Van and Modified Van	Gasoline	8.9
Body on Van Chassis	Gasoline	6.5
Body on Truck Chassis	Gasoline	5.1
Purpose Built	Gasoline/	3.6
	Diesel	6.1

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[1] "Small Transit Vehicles: How to Buy, Operate and Maintain," by A. B. Boghani, et al., NCTRP Report #11, Transportation Research Board, Washington, D.C., January, 1985.

APPENDIX B: FORMS FOR LIFE CYCLE COST CALCULATION

FORM 1: AVERAGE WEEKDAY RIDERSHIP

	500 ft	700 ft	1000 ft
Convenient Walking Distance	______	______	______

Population within Convenient Walking Distance (catchment area) ______________

Route Type

Loop ______

Lollipop ______

Linear ______

Population Characteristics

	high	low
Age Level	______	______
Income Level	______	______
Car Ownership	______	______
Student Population	______	______
Proportion of Single-family Dwellings	______	______

Catchment Factor (Table 2) ______

Catchment Factor ________ x Population in the Catchment Area ______

= [______ | b]

Average weekday ridership

FORM 2: TIME TABLE AND NUMBER OF BUSES

Headway (Table 3)

	Headway	Buses/Hr
Peak Hours (8:00-8:59 a.m., 5:00-5:59 p.m.)	______	______
Base Period (6:00-7:59 a.m., 9:00 a.m. - 4:59 p.m.)	______	______
Evening Hours (6:00 p.m. - midnight)	______	______

Timetable

Route__________ From__________ To__________

Monday Through Friday

Leave Leave

________a.m. ________a.m.

Round trip time (peak hour) ____________
______________________________________ = [| a] No. of Buses Required on the Route
Headway (peak hour) ____________

Round off to next larger integer

FORM 3: BUS CAPACITY

Number of Inbound Trips Before Noon			Number of Outbound Trips After Noon							
Time	No.		Time	No.		Total				
8:00 - 8:59 a.m.	_____	+	5:00 - 5:59 p.m.	_____	=	_____	x	1	=	_____
6:00 - 7:59 a.m. and 9:00 - noon	_____	+	noon - 4:59 p.m.	_____	=	_____	x	0.5	=	_____
			6:00 p.m. - midnight	_____	=	_____	x	0.25	=	_____
			Equivalent Load		=					_____

Average weekday ridership (from Form 1) [b]

———————————— = _____

Equivalent Load (from above) _____

Number of passengers per week hour trip in peak direction

Bus Capacity Required [c] =

FORM 4: SEATING PLAN AND BUS LENGTH

Bus Capacity Required (from Form B) [______ c]

Check Seating Plan Selected
______ 2 and 1
______ 2 and 2

Bus Capacity Required ÷ [1.5 (if 2 and 1 seating plan) / 1.25 (if 2 and 2 seating plan)] = [______ d] No. of Seats Required

No. of Seats Required ÷ [3 (if 2 and 1 seating plan) / 4 (if 2 and 2 seating plan)] = [______ e] No. of Rows Required

No. of Rows Required ______ X 3 = [______ f] Bus Length Required

FORM 5: INITIAL BUS SELECTIONS

Buses Under Consideration

Bus Make/Model	Capacity	No. of Seats	No. of Rows	Length
Requirements (from Form 4)	c	d	e	f

Initial Bus Selection

Bus Make/Model	Number Needed	a (from Form 2)
______	______	
______	______	
______	______	
______	______	

You may want to go back to Form 2, change headway, and repeat the entire process:

Bus Make/Model	Number Needed
______	______

FORM 6: ALTERNATIVE CANDIDATE BUS FLEETS

Alternative	Bus Make/Model	Number of Buses
1		
2		
3		

REFERENCES

1. "Planning Transportation Services for Handicapped Persons - User's Guide," by F. J. Wegmann et. al., NCHRP Report #262, Transportation Research Board, Washington, D.C., 1983.

2. "Small Transit Vehicles: How to Buy, Operate and Maintain," by A. B. Boghani et al., Transportation Research Board, Washington, D.C., January, 1985.