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ASSESSMENT OF URBAN ROAD TRANSIT BETWEEN 1980 AND 1990

U.S. DEPARTMENT OF TRANSPORTATION
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION
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U.S. DEPARTMENT OF TRANSPORTATION
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PREFACE

The assessment of urban road transit was initiated, sponsored, and guided by the UMTA's Office of Bus and Paratransit Technology. The Transportation Systems Center (TSC), Urban Systems Division, performed the assessment during the winter of 1979-80 with support from the MITRE Corp., Booz-Allen and Hamilton, and Capital Consultants. This study represents the first phase of the comprehensive, continuous assessments that are required in order to develop better understanding and insights on the problems and issues, currently and for the foreseeable future, affecting urban road transit.

The majority of this report is focused on the standard size city coach (35-40 feet), the workhorse of urban road transit in the United States. Paratransit is addressed to a lesser degree due primarily to the lack of good aggregate data. Similarly, a relatively small amount of attention is given to large and small capacity vehicles, although service utilizing these vehicles shows good potential for growth in the future. Clearly, issues and problems regarding supply and demand, manufacturing dynamics, vehicle performance, costs, and the role of "non-standard" road transit vehicles should be addressed just as completely. However, time did not permit such an all encompassing assessment. Therefore, this report should be viewed as a window, albeit a large one, on the public transit environment in the U.S.; there are other views from other windows and the environment is continually changing.

Contributors to this assessment report include Martin Anderson, Leonard Bronitsky, Judith Gertler, Richard Gundersen and Harold Miller, all from the TSC; Dennis Symes from UMTA; and Peter Wood and Marcel Zobrak from MITRE Corporation. Dr. Frank Tung, Chief of the Urban Systems Division, TSC, served as project Director. Raytheon Technical Services Division of TSC provided typing, graphic and editorial support.

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SUMMARY

Many changes have occurred in urban bus transportation since the passage of the Urban Mass Transportation Act in 1964. The downward trend of bus ridership has been reversed. Federal funds have been used to purchase almost 40,000 new buses in over 300 transit systems. New servicing and maintenance facilities have been introduced, replacing buildings which, in some cases, had been in use since the turn of the century. New bus designs were introduced by two U.S. manufacturers. Articulated buses are now being used in several cities. Innovative operating procedures such as dedicated bus lanes on freeways, and contraflow operation on city streets, have been tested and their value as a technique for encouraging transit ridership clearly identified.

These events and changing circumstances have created a need for the Department of Transportation (DOT) to reexamine the future of urban road transit and the attendant requirements placed on the Federal Government. This report is a review of the actions that should be taken by DOT/UMTA based on an assessment of the current status of road transit, coupled with market projections for the 1980-90 time frame.

Recent industry reports estimate the nation's fleet at about 52,500 vehicles, of which over 90 percent are classified as standard (35 and 40 feet) city coaches. Less than 500 are high capacity vehicles (articulated and double-deck buses), about 650 are trackless trolley coaches, and the remainder consist of small bus designs. Extrapolation of available data indicates that during 1979 approximately five billion linked passenger trips were made by bus mode, and vehicle utilization averaged 34,000 miles per year. About one-third of the fleet currently is more than 12 years old.

Four possible scenarios are used to project conventional bus fleet requirements from 1980 to 1990. The fleet requirements, in turn, create requirements for yearly vehicle orders and funding. The scenarios chosen to develop these fleet requirements represent a range of hypothetical environments identified to bound the problem rather than suggest what may happen.

The 1990 transit bus fleets envisioned under the study are as follows:

<u>Scenario I</u> - 42,000 to 54,000 vehicles by 1990 based on freezing the

Federal capital assistance at the estimated 1980 level for the next decade (constant 1980 dollars). The marginal expansion (i.e., an additional 1500 buses) is realized through major replacement by vehicle refurbishment.

Scenario II - 70,000 vehicles by 1990 based on projecting 1972-80 ridership trend increases of 4.3 percent annually through 1990.

Scenario III - 88,000 vehicles by 1990 based on an increase of 50 percent in transit capacity (vehicle-miles) by 1990 and occurring entirely within the bus mode. This results in a 70 percent increase of bus service capacity.

Scenario IV - 115,000 to 160,000 vehicles by 1990 based on increasing the bus mode share during the peak period from the current level of 10 percent to 30 percent by 1990.

The major findings of this study are provided below in narrative form. More detailed Federal options associated with each finding are provided in the accompanying summary chart.

1. It is reasonable to expect that the 1990 fleet will lie somewhere between Scenario II and Scenario III based on the recognized need to provide sufficient road transit capacity to meet growing ridership demands created by international and domestic energy policies. These two scenarios imply a growth from the present U.S. ratio of buses per million urbanized population of 375 to a projected ratio of 430 for Scenario II (similar to Cleveland, Ohio) and 540 for Scenario IV (similar to the New York-New Jersey region).

2. Unless something happens to substantially increase competition, it is anticipated that the Advanced Design Bus (ADB) will represent the large majority of standard transit vehicles ordered with a continuing small market for the "New Look" design. Factors that may strongly affect this finding include the acceptance of foreign technology for U.S. road transit and the potential emerging demand for small and large capacity vehicles. While the refurbishment market looks strong in the scenario with low Federal assistance (I), no large growth in that market is anticipated in cases of adequate financial subsidy.

3. Small and large capacity vehicles currently account for less than 10 percent of the total U.S. fleet. The market share for these vehicles is expected to substantially increase in the 1980s. Although the exact magnitude

of the increase is uncertain, it is reasonable to expect their combined share to fall within 14 to 30 percent of new vehicle orders. Potentially, this could mean that annual new orders for small and large capacity vehicles could reach in excess of 1700 and 400, respectively.

4. Advanced design bus orders reach an average of 2000 vehicles per year for Scenario I, 4100 vehicles per year for Scenario II, 5850 vehicles per year for Scenario III, and as high as 11,700 vehicles per year for Scenario IV. From the perspective of the present two-vehicle manufacturers, with each one theoretically having three-shift production capability, these requirements can be satisfied with one, two, three, and six production shifts, respectively.

5. It is unlikely that a third manufacturer of an advanced design bus would enter the market under Scenarios I and II. It is also improbable under Scenario III since the necessary production capacity can be achieved through additional shifts at one or both of the existing manufacturers. The entry of a third standard size coach manufacturer might be warranted under Scenario IV where potential yearly orders could exceed 11,000 vehicles per year. The way manufacturers perceive the bus market and the subleties of industrial decision-making obviously are not easy to predict; however, evidence the fact that Gillig Corp. and Neoplan are planning U.S. production of standard city coaches and GM has started a second production shift.

6. Existing production capacity for small capacity vehicles appears adequate for Scenarios I and II. It is uncertain whether nationwide production capacity can meet market demands in excess of 600-800 units per year. However, space and labor in existing production facilities can be expanded to meet higher demands of Scenario III. Additional capacity most likely will be required for small transit coaches under Scenario IV.

7. Large capacity vehicle production is currently governed by foreign supply of the basic vehicle. The now terminated joint venture of AM General and M.A.N. of Germany was capable of producing up to 750 articulated vehicles per year, sufficient to meet market demands of all scenarios. With adequate demand (and funding), foreign production of large capacity vehicles from companies such as M.A.N., Ikarus, and Neoplan in joint venture with American firms, or other means of compliance with the "Buy American" provisions, appear sufficient for any foreseeable demand.

8. Road transit vehicle refurbishment appears to be a viable alternative to new vehicle procurement in meeting the nation's fleet capacity needs. However, premature reliance on this industry for substantial numbers of rebuilds may be fraught with problems. Bus rebuilding capacity, whether by transit properties or private contractors, appears constrained by lack of available skilled personnel. Bus rehabilitation does not inherently lend itself to volume production because industry practice is to repair or replace components on the basis of condition which cannot be fully determined until after partial tear-down. Other problems apparently inhibiting major capacity increases includ: the lack of precise definitions of and specifications for vehicle rehabilitation; non-uniformity of warranty provisions; restrictive union agreements prohibiting contracted repair; and consideration of emergency stockpiling instead of rebuilding.

9. With changing travel patterns favoring the lower density routes and the increased emphasis on productivity, substantial fleet shares for both small and large capacity vehicles, over that presently experienced, are probable. These two vehicle markets, together wtih the vehicle refurbishment industry, could provide excellent competitive stature to the now oligopolistic city coach supply.

10. Manufacturing capacity is relatively easy to expand due to the labor intensity of final bus production. Decision by manufacturers to invest in new increments of production cannot be made on short-term promises of unit demand. Therefore, the most critical determinants of long-term bus capacity are <u>volume</u> of demand, <u>duration</u> of demand, and the <u>certainty</u> of these factors.

11. There are no known capacity constraints for the supply industries for Scenarios I, II, and III. However, parts suppliers make independent assessments of transit vehicle demand. If the suppliers' estimates fall short of final assemblers' estimates, it is possible that suppliers' estimates will constrain. Also, bus volume alone is not enough to stimulate heavy machine tool investment, and to the extent that future bus products are made unique from trucks, capacity can also be constrained.

12. If no additional Federal capital funds were provided (that is, the level provided by the current Surface Transportation Assistance Act was maintained, indexed to inflation, but there was no contribution from the Energy Security Fund), only fleet requirements for Scenarios I and II could

be satisfied. The average age of buses would increase. Addition of the money from the Energy Security Fund at an average of 350 million constant 1980 dollars per year would permit purchase of additional vehicles to both increase supply and reduce the average age of the fleet. The total amount of Federal capital assistance, however, is not sufficient to fund the fleet requirements consistent with Scenarios III and IV. The required Federal capital contribution ranges from $1.2 to $1.6 billion for Scenario III and $2.4 to $3.2 billion for Scenario IV. Also, the required state and local matching capital funds, which would escalate from the current level of approximately $150 million nationwide to as much as $800 million in the high case of Scenario IV, may constrain the 1990 fleet size.

13. Operating and maintenance costs will continue to increase as a result of the additional service being offered and will be the major deterrent to expanded services. If the fare box and miscellaneous revenues continue to cover only 40 percent of O&M costs, annual operating deficits by 1990 will amount to $2.2 to $3.1 billion nationwide for Scenario I, $3.6 billion for Scenario II, $4.7 to $5.1 billion for Scenario III, and as high as $9.2 billion for Scenario IV (all in 1980 dollars). With the current level of Federal assistance for bus transit operating expenses estimated at $0.85 billion and with Congressional opposition to allocating Energy Trust Fund money to increase this assistance, the state and local burden could rise from an estimated $1.6 billion in 1980 to $2.75 billion for Scenario II, $3.75 to $4.25 billion for Scenario III, and as high as $8.35 billion for Scenario IV by 1990. Substantial efforts by all entities involved in public road transit, incluidng the Federal Government, are needed to identify and deploy technology and improved personnel resource management to lower O&M costs. In addition, strong consideration must be given to increasing fares in response to inflation and improved services.

14. Currently, the demand for public road transit for the peak period work trip, commonly used to establish fleet needs, comes mainly from trips within the central city (5.7 percent of all metropolitan vehicle work trips) and suburb-to-central city (1.9 percent of metropolitan vehicle work trips). However, the statistics on the total work trips indicate that the market offering the greatest growth potential is the suburban-to-suburban work trip. This category of trip suggests the use of different types of vehicles than the standard transit bus and offers great potential for part-time drivers.

15. It is unlikely that the advance design bus will be the subject of any major technological improvements. Most of the current problems will be eliminated through conventional product improvement programs. Future regulatory requirements, particularly the noise standard of 1985, may be difficult to meet. Compliance with future emission standards will result in increased fuel consumption. This may be offset to some extent by the use of a recently introduced, more efficient engine and by a weight reduction program carried out by the manufacturers.

16. Improved accessibility for the mobility handicapped and improved access/egress for the general public should be recognized as distinct and separable. Improved accessibility for the mobility handicapped will be achieved by the U.S. manufacturers through the reduction of vehicle floor height to 24 inches or lower (kneeled) and by improved and more reliable lift designs. Further reduction of floor height of domestic city coaches (below 24 inches) to provide major improvement in accessibility for the general public or the mobility impaired can only be achieved through a major retooling. More data are required to quantify the benefits of a low floor (16 inch kneeled) since it is not essential for wheelchair accessibility.

17. A shift to eight cylinder diesel engines and the inclusion of the air conditioning accessory is responsible for the marked increase in fuel consumption per vehicle-mile in many transit operations. The new generation ADB has been reported to consume up to 25 percent more fuel per mile than the new look bus. Diesel fuel prices continue to escalate and higher bus utilization is being demanded. Improved fuel economy for road transit vehicles represents a systems problem that requires complex trade-offs in emissions, performance, and cost. Vehicle weight reductions could reduce fuel consumption by approximately one percent for each 1500 pounds removed. Reducing the power requirement of the air conditioner system from the approximate 20 percent of total average power would permit small engine sizing. However, any major improvement in fuel economy can only be achieved through a completely new propulsion system and vehicle design.

18. Prior to embarking on any major new bus development program, an intensive assessment of the European bus manufacturing industry should be performed to identify the possibility of technology transfer. This should include an assessment of the design and manufacturing philosophy adopted by

European manufacturers (system design versus subsystem assembly, dependence on components supplied by the trucking industry, etc.). In addition, the performance, costs, and acceptability of selected European vehicles should be quantified by demonstration and analysis in order to identify and stimulate technological improvements leading to the domestic production of road transit vehicles with high fuel efficiency, low life-cycle costs, and maximum accessibility and comfort for both general public and mobility impaired passengers.

19. At present, there is considerable controversy on what constitutes an "acceptable" bus. In addition, there is diverse opinion whether or not vehicle procurements based solely on low bid properly compensate a manufacturer or component supplier for a superior product. One approach to resolve these issues, at least in part, is to specify an "acceptable" bus and condition vehicle procurements on a life-cycle cost basis. There are, however, little actual data available to allow for the introduction of life-cycle costing techniques. Much of the confusion will be alleviated through the following recently established UMTA programs: (a) Transit Bus Quality Program; adopting a uniform procedure for inspection of bus quality and for setting up an independent organization to monitor manufacturing processes; and (b) the Transit Reliability Information Program where a significant amount of information based on actual histories relating to maintenance actions and replacement parts will be provided. Furthermore, with Federal and local budgetary constraints getting tighter on the one hand and transit properties experiencing difficulties in funding and retaining qualified mechanics on the other, the trend appears to be toward a functional and simple bus providing basic transportation rather than style, reliability rather than comfort, performance rather than sophisticated technology, and proven components rather than experimental.

20. Improved management information systems are essential. Improved data on operations (ridership/revenues/costs/vehcile miles) are essential to improve resource allocation. Real-time control and data collection systems are essential to improve quality of service by improved schedule maintenance and to reduce over-loading. Passengers should have ready access to real-time data on service rather than scheduled information.

21. Passenger facilities need to be improved and a sheltered accommodation at virtually every stop is desirable.

22. Productivity improvements can be achieved through increased use of part-time labor, more efficient use of both personnel and equipment, and by aggressively introducing new operating procedures such as subscription services. High capacity buses should be increasingly used on high density routes, along with the increasing use of small buses on less dense routes. Experience in foreign countries should be examined to provide insights on managing heavily utilized bus fleets since typically, European cities have two and sometimes three times the number of buses per capita with exceedingly higher annual bus rides per capita than U.S. cities.

23. At the state and local level, variations in local regulations, such as bus widths, axle weights, safety requirements, etc., will inhibit the procurement of a fully "standardized" vehicle. The evolution and acceptance of a basic, functional, standard bus requires action and cooperation at the local level.

24. There will be an increasing tendency towards decentralization of transit providers, and frequently, services will be provided through a "brokerage" approach rather than a single publicly owned transit operator.

25. Although there is not sufficient aggregate data on paratransit services to meaningfully permit conclusions or predictions, it is reasonable to expect substantial growth in paratransit services due to the changing economic environment and domestic energy policies. Paratransit services in the form of demand-responsive transit, conventional and shared-ride taxi and other special services, such as carpooling and vanpooling, represent a viable and often a relatively economic method of providing transportation for those segments for which conventional transit is unsuitable. In addition to anticipated large increases in car/vanpooling over the next decade, major growth is expected in special service, doorstep service for the mobility impaired due mainly to recent actions related to Section 504 of the National Rehabilitation Act. General public services, such as checkpoint paratransit, offering higher productivities must be deployed in order to efficiently meet the emerging demands in the lower density areas.

SUMMARY CHART

Potential Federal actions have been organized into three categories:

I. System Analyses, Assessments, and Deployment
II. Vehicles, Subsystems, Facilities, and Wayside Technology
III. Operational Technology

I. SYSTEM ANALYSIS, ASSESSMENTS, AND DEPLOYMENT

Options in this area address programmatic analyses that are prerequisities to major system, subsystem, and technology development. This category encompasses assessments of road transit products, research payoffs, and associated industries and existing technology.

Brief Statement of Findings	Brief Statement of Potential Federal Action
a. A major increase in operating deficit is imminent. Operating deficits are the most significant constraint to major bus service expansions and innovative service.	Increase available Federal assistance for operating subsidy; identify operational improvements, equipment, techniques to lower O&M costs, encourage local governments to raise fares commensurate with inflation and improved service; increase productivity by promoting planning and coordination of human resource development for road transit.
b. Competitive structure of standard coach supply continues to deteriorate and capital costs continue to escalate. Stable (5 years or more) order rates of 5000-6000 vehicles per year appears necessary to encourage third manufacturer or an additional shift.	Guarantee level of demand and duration of demand through adequate level of funding for bus purchase. Assess multi-year procurement policy and procedures to permit smoother yearly order rates and assess recent APTA procurement policy statement. Provide visibility of new foreign design approaches for consumers and manufacturers alike through a vehicle demonstration program.
c. Need to recognize and address new markets in suburban work trips.	Closer examination of the characteristics of suburban work trips and the attendant fleet mix requirements.
d. Any accommodation of expanded transit and increased ridership demands will likely take place within relatively unchanged institutional settings. Policy, planning, programming, funding, regulatory, and operating responsibilities and authorities will continue to be fragmented.	Develop better understanding of local institutional settings to guide Federal policy and financial assistance and deployment of research. Identify mechanisms to aggregate transit responsibilities (such as brokerage concept). Identify means of reducing delay in grant submissions processing and pro-

	curement actions. Promote discussion among concerned users, suppliers, manufacturers and government through periodic road transit conferences.
e. A great deal of confusion as to what constitutes an "acceptable bus" and present vehicle procurements do not properly compensate superior products.	Re-examine the equity and timeliness of price off-sets; establish life-cycle costing in bid selection; promote uniform procedure for inspection. Evaluate use of two-step procedure for vehicle procurement.
f. European operations deploy a greater number of buses per capita than U.S. transit operations, as well as a larger proportion of higher capacity vehicles. Current European bus systems may represent the scale of operations that will be obtained in the U.S.	Initiate research to assess selected European operations to identify equipment, techniques, and procedures to improve operational efficiency in U.S. operations.
Based on many of the findings of this study, there is a need for well organized research that is responsive to near-term problems and adaptive to the longer-range issues facing the Department.	Develop a coherent RD&D plan for urban road transit to address problems and issues, such as those identified in this report, and prioritized according to goals and objectives of the Department.

II. VEHICLES, SUBSYSTEMS, FACILITIES, AND WAYSIDE TECHNOLOGY

Options in this area address research to improve vehicles or components in an attempt to reduce vehicle life-cycle costs, and improve performance. In addition, this category includes efficiency and performance improvements for road transit facilities and wayside equipment and structures, as well as the development of information, guidelines, or technology to permit more effective use of capital.

Brief Statement of Findings	Brief Statement of Potential Federal Action
a. There are numerous technical problems associated with the ADB. Most notable are poor brake life, poor fuel economy, excessive tire wear, and subsystem unreliability.	Take the leadership initiative and, together with equipment manufacturers and appropriate technology committee, coordinate and monitor problem resolutions and hardware improvements.
b. Noise standards may be difficult to meet.	Assess the technical difficulty and identify methods and costs to comply with standards.

c. It is unlikely that the diesel engine will be replaced as the power plant in the next decade and meeting emission standards conflict with performance goals.	Develop more information to quantify this finding. Seek technology and information transfer from related work on propulsion systems. Continue to assess diesel pollutant issue in conjunction with appropriate agencies/groups. Coordinate with other issues for transit bus conferences.
d. Vehicle refurbishment most likely will become more important.	Reexamine "Interim Guidelines;" examine refurbishment certification needs. Examine bus rebuilding industry as one of the important sources of supply in the road transit system. Assess economic and service value of stockpiling as an alternative/adjunct to rebuilding.
e. Absence of sufficient empirical data, together with increased emphasis on alternatives, create serious doubt on need of lowering floor height beyond the current 24-inch kneeled floor.	Continue to evaluate handicapped and elderly design requirements and mobility options; assess other benefits of low floor buses. Incorporate assessments of the acceptance, suitability, and "value" of European low floor vehicles into a National Bus Demonstration Program.
f. Wheelchair lift reliability appears to be a problem.	Establish reliability and cost data on lifts. Encourage manufacturers to continue improving system design and incorporating consumer preferences. Assess result of ongoing test.
g. Some improvements appear possible within the 3-5 year time period with government support.	Perform research in selected component areas, such as low profile tires, more reliable electrical systems, better cooling and brake systems, vehicle retarder systems, air conditioning cut-off during acceleration, and constant speed accessory drives.
h. Continuous variable transmissions and other advanced transmissions, which hold the greatest hope for improving driveline efficiency, could be available for road transit during the next decade with significant research and development support.	Define state-of-the-art in transmissions and drivelines; quantify improvements; identify and perform research where warranted to expedite deployment in road transit application.
i. There has been a general weight increase in transit coaches of approximately 5000 pounds since the 1950s, due primarily to deployment of air conditioning and larger engines.	Determine reasonable boundaries for weight reductions; identify and quantify (possibly through experiments) impacts of life-cycle cost associated with reducing weight.

Brief Statement of Findings	Brief Statement of Potential Federal Action
j. Strong consideration must be given to the use of petroleum-independent power plants for the next generation transit vehicles.	Reassess road transit drive cycle requirements. Reassess accessory power load requirements. Investigate next generation city coach as a new vehicle design promoting standardized, light weight, low floor design with petroleum independent propulsion.
k. Many transit properties use Federal capital subsidy (80 percent share) as a justification to specify "nonstandard" items in their procurement of city coaches. Standardization of vehicles procured with Federal grant assistance can only be approached through cooperation of local transit operators.	Encourage re-evaluation of local public utility laws impacting the cost of new vehicles. Identify and implement tighter grant and vehicle specification review to reduce Federal subsidy for nonstandard items.
l. The market share of small and large capacity vehicles is expected to increase in the 1980s. Unlike the standard city coach market and production facilities, which are relatively well established, the small and large capacity vehicles are at a stage to permit serious consideration of standardization.	Investigate the potential for standardization of designs for small and large capacity categories of vehicles.

III. OPERATIONAL TECHNOLOGY

Options in this area have as their primary objective the improvement of road transit operations in response to the changing nature of transit demand. Included in this category are items that could potentially improve the reliability, performance, productivity, or efficiency of overall vehicle transit operations. Emphasis is on controlling or reducing operating management and maintenance expenses associated with these systems, as well as providing the type of service demanded by transit patrons.

Brief Statement of Findings	Brief Statement of Potential Federal Action
a. Need to encourage improved productivity in all areas of transit operations, maintenance and management.	Encourage use of high capacity vehicles, where justified; institute productivity measures as incentive for supplemental funding; consider providing training programs for innovative bus maintenance utilizing improved procedures and equipment; assess usefulness of funding all or greater portion of management training programs. Continue to assess and

	encourage appropriate fleet mix for demand levels and market types, i.e., identify methods to obtain better utilization (rides per revenue mile).
b. Some fuel efficiency improvements appear possible through weight reduction and improved engines.	Perform research and evaluation of city coaches under various weight reduction situations; perform engine improvement research; interface with DOE projects.
c. Major improvements in performance and fuel economy only possible through completely new vehicle.	Continuous assessment of foreign technology related industry improvements (materials, propulsion, etc.). Currently, no need to initiate new vehicle development program.
d. Service records or inventory or operational parameters must be more closely tracked to permit identification of improvements in life-cycle costs. Presently, no data exist with which to make any findings concerning LCC.	Continue the present UMTA program establishing maintenance and operational data collection and analysis systems for transit properties.

1. INTRODUCTION

1.1 BACKGROUND

In recent years the concern over several National issues has intensified resulting in serious implications for urban road transit systems. The issues impacting public road transit and consequently creating new or, at a minimum, expanded needs or requirements, include:

- Energy/Petroleum. The transportation sector, in which the private auto plays a substantial role, accounts for approximately 50 percent of the annual petroleum consumption nationally. Reduction in petroleum imports is a high priority National objective. A shift in ridership to public transit will help to attain this goal. As a result of escalating fuel prices, fuel availability coupled with Federal and state policies, such a shift is slowly occuring and needs to be accelerated. In addition, the petroleum shortage will focus more emphasis towards improvements in energy efficiencies of transit operations as well as the development of alternative systems.
- Regulatory Compliance. While regulatory and administrative requirements are imposed to protect the public interest, sometimes their rigid applications results in costs that outweight the benefits. The operating environment, as well as social pressures influencing road transit, are continually changing and so too should many of the government controls. However, regulatory action taken to support one objective may have an adverse impact on other objectives. Although all areas currently regulated are important, it appears that more attention will be focused on issues of energy conservation, diesel air pollutants and fuel accessibility for the elderly and handicapped.
- Productivity and System Efficiency. With increasing ridership demands and inflationary pressures on transit operating budgets, a major issue of concern to operators and the paying public is how to improve transit productivity and operating efficiency.
- Private Sector. Over the past decade the ability of the transit supply industry to meet the demands that will be imposed upon them in the

future has been seriously impaired. With the exception of the Advanced Design Buses currently being manufactured by General Motors and Grumman Flxible, all road transit vehicles now being purchased in the United States are either of foreign manufacture (e.g., "new look" buses) or of foreign design ("Citycrusier"). At the same time, costs of buses have increased at a rate much higher than inflation and the low-bid approach to procurement reduces the incentive to introduce improvements that could ultimately result in reduced life cycle costs. Much more emphasis needs to be placed on understanding the dynamics of private industry and the technique for the successful deployment of technology.

- Service Quality and Availability. In many respects the needs perceived by transit riders are diametrically opposed to those of the transit industry. Riders would like frequent, convenient service at low cost. Transit operators need to carry the maximum number of riders at the lowest operating cost. As a result, transit systems largely concentrate on the segment of the market that is easiest to service--the journey to work. Increases in ridership will require services to be provided for other market segments, where traditional types of service may not be cost effective.

  Services for the transit dependent market may also require adoption of new techniques. In addition, improvements in service quality for a significant portion of the potential market, the non-wheelchair ambulatory impaired, will require improved accessibility.

In view of the issues above, it is necessary for UMTA periodically to assess where we are in public road transit, where we appear to be going, and what the needs and issues are that require Federal action. This assessment report represents a first attempt at developing such information.

This report, together with UMTA's (UTD) "Bus Procurement Policy and Plan" and "TRANSBUS Options Paper," represents the basis and justification on which to structure a coherent RD&D plan for urban road transit. These referenced documents address the more immediate needs facing UMTA, while the Assessment Report covers perceived requirements for the decade.

1.2 DEFINITION OF URBAN ROAD TRANSIT

Urban road transit includes all forms of ground transportation of passengers, primarily between points within an urbanized area, that are available on a regular basis to anyone paying the prescribed fare or who otherwise meets the requirements for use, and that do not operate on a fixed guideway. Unlike rail transit, road transit offers a wide variety of services that can be broadly described as follows:

a. <u>Fixed-route service (Conventional)</u>

Conventional fixed-route services operate on routes and schedules generally established and set not more than four times per year. Such services have the legal status of public utilities or common carriers and take many forms, including:

1. Bus rapid transit using motor buses and operating wholly or in part on separate rights of way or exclusive lanes, with limited stops.
2. Express bus service operating wholly or in part in mixed traffic or freeways or arterial streets, with limited stops.
3. Local service using motor buses on arterial and city streets with frequent stops.
4. Circulation systems using motor buses and providing a sollection and distribution service within a limited area.

Vehicle types used in these fixed route services normally include:

- High capacity vehicles with more than 69 seats; either an articulated or double deck design.
- Standard city coach with 45-54 seats, typically 35-40 feet long, 96 or 104 inches wide, designed for frequent stops or high speed freeway operation.
- Small bus with a capacity of approximately 30 passengers built using transit bus techniques.

b. <u>Flexibly-routed Paratransit Service</u>

Flexibly-routed paratransit services are available to anyone desiring to make use of them, on payment of a fixed fare. This category includes:

1. Taxicabs. These provide service on demand between points within an urbanized area, at fares prescribed by public authorities, and measured by metering devices or zone systems. Shared-ride taxicabs provide group service to different destinations. Automobile size vehicles are used.

2. Jitneys. These services use passenger cars or van-type vehicles equipped with seats. They run to some extent on fixed routes and with uniform charges, and generally compete with fixed-route and scheduled service provided by mass transit operators. They may be regulated, or in unauthorized operations.

3. Dial-a-ride. These services provide a demand service between points within an urbanized area at a prescribed fare. Small buses and vans are used and the vehicles are dynamically scheduled to maximize ride sharing.

4. Elderly and Handicapped Services. Specifically equipped vehicles provide scheduled or on demand services to those who, due to disability or lack of accessibility, are unable to use fixed route and scheduled service.

5. Special Interest Transportation. These passenger services are related to state, Federal, or non-profit agencies whose primary purposes include providing health care or other social benefits rather than the transportation itself.

6. Subscription Service. Special motor bus service provided to and from major activity and employment centers, that is normally available only on a prepaid fare basis. Normally this is a limited frequency, fixed-route service.

7. Vanpools. Special service using multi-seat vans to and from major activity or employment centers. The vehicle is normally driven by the owner of the van, and provides one round trip each day on a fixed route to an approximate schedule. Service is commonly only available on a contract period basis.

Vehicle types used in this service include:

- Mini buses, custom designed with a capacity of approximately 20 passengers. Vehicle may use custom-built body on a commercial truck chassis.

- Vans adapted to carry up to 12-18 passengers
- Limousines or standard autos.

This variety of road transit services along with rail transit running on fixed guideways comprise the entire urban public ground transportation service. Although many of the services described above are tailored to particular needs, they constitute part of a total systems that need to be better integrated and coordinated. Progress in service integration, however, has been slow. System integration is now being aggressively pursued in many communities and is expected to be widespread in the years to come.

1.3 OBJECTIVE

This study defines the potential role of public road transit for the 1980's and identifies Federal actions that appear necessary or beneficial to this emerging role. Such assessments, performed periodically, should constitute the basis for the formulation and update of policy and plans, projections of financial assistance, and conduct of research, development and demonstrations.

1.4 SCOPE

This assessment was based on an examination of current operating characteristics, demographic trends, industrial dynamics in the conventional transit vehicle and component manufacturing industry, and state and local initiatives and constraints. For the fixed-route element, a parametric analysis (macro-analysis) was performed based on an understanding of where the road transit system stands today and where (hypothetically, yet very realistically) road transit could be by 1990, it is possible to identify issues and problems that require attention at the Federal level during the next 10 years. The hypothical situations or scenarios translate into requirements for fleet size. Fleet size, in-turn, drives capital and operating subsidies for both the Federal and local share, manufacturing markets, technological needs, and productivity improvements.

For the paratransit element, operating characteristics, trends and aggregate data were obtained and analyzed, when the information was available.

Paratransit scenario discussions, based extensively on existing studies, are provided.

The report consists of five chapters. Chapter 2 provides a picture of the fixed-route element of urban road transit, past and present. This is followed by the development of scenarios intended to "scope" estimates for urban fixed-route capacity requirements for the next 10 years. Four scenarios ranging from a very conservative no funding growth to a 300 percent increase in mode split are used. Impacts resulting from these scenarios are estimated in the form of fleet size, funding, maintenance/operations/management, and vehicles and subsystem manufacturing. Chapter 3 addresses the status of paratransit services, with the recognition that this area is complex, relatively new, continually changing and not as well structured as the fixed-route services. Projections into the 1980's based on existing studies are provided. Discussions of a qualitative nature concerning where the paratransit growth potential exists are also given. Chapter 4 summarizes road transit needs and issues. Chapter 5 provides the study findings and recommended Federal actions.

In addition to the main text, this report also contains a number of self-contained appendices. Appendix A provides a background discussion on local issues as they affect public transportation. Appendix B gives a block diagram view of the steps involved in the grant process and the times that are normally involved in each step. Appendix C provides available data on vehicle production in Europe. Appendix D discusses background information on transit vehicles and selected subsystem supply industries. Appendix E covers the vehicle rebuild industry. Justification for operating assistance values used in this study is given in Appendix F. Bibliography or relevant contemporary literature is given in Appendix G.

It is worth noting that this report is not an end to itself. While it can be used to guide decisions in the near-term, it should be subjected to a continued updating or revision to guide decisions further in the future.

2. FIXED-ROUTE SERVICE

Over 1000 operating transit systems nationwide provide motor bus service along fixed routes and according to predetermined schedules. Currently, about 75 percent of all transit rides are on fixed-route bus. The following information is provided to highlight problems and issues currently plaguing the Nation's fixed-route bus systems. All reference to road transit vehicles or buses in this section is intended to mean conventional motor bus or trackless trolley service.

2.1 RIDERSHIP

As indicated earlier, the embargo on petroleum shipments to this country in 1973 was a milestone in the history of bus transit. It triggered a turnaround in the quarter century trend of declining ridership. But if the embargo was a milestone for transit in general, it was an even greater milestone for road transit. All the increase was in the road-service component, and within it, in-bus service. As shown in Figure 2-1, bus ridership was at an all time low of 3.56 billion trips in 1972 and increased to 4.41 billion in 1978. This represented an increase of 24 percent over the last 6 years, or an equivalent growth rate of about 3.7 percent per year, compounded. Although there are between four and five billion trips made each year by bus, that number is in fact a small percentage of all urban travel. Figure 2-2 shows the distribution of urban work trips as obtained from two sources.* In one case, based on a sample drawn from 41 Standard Metropolitan Statistical Areas (SMSAs), road transit work trips accounted for 8.2 percent of all work trips. In the other case, based on a sample from all SMSAs, road transit accounts for only 4.2 percent of all work trips. The difference lies in the fact that the sample from 41 SMSAs includes data from most of the nation's large cities including New York, Philadelphia, Chicago, and Cleveland where the percentage of trips made by transit is known to be considerably higher.

The implication of the information in Figure 2-2 is that transit, both road and rail, has a substantial source from which to draw additional riders;

*Only work trips are considered here. The implications of the data, however, remain the same for either nonwork or total trips.

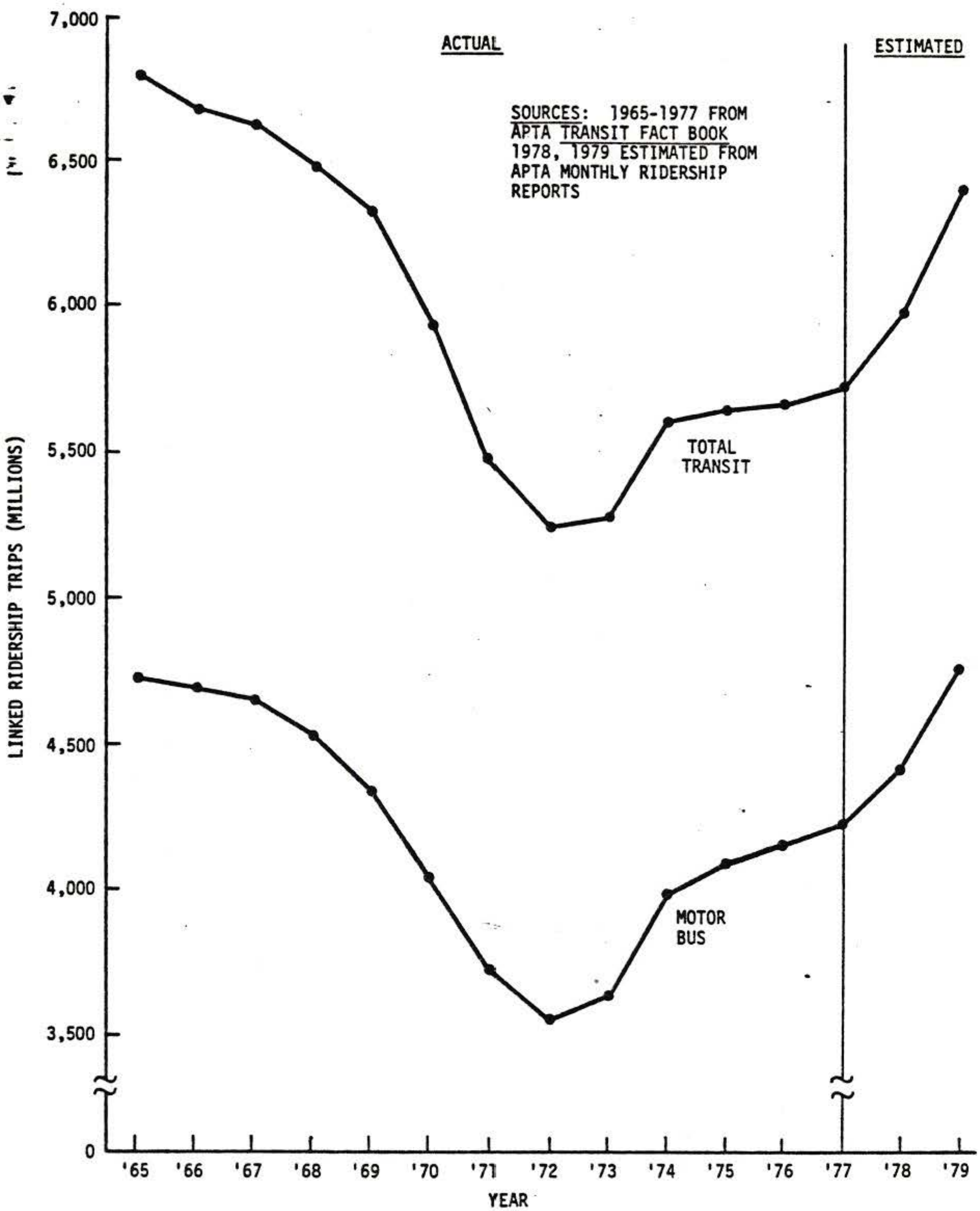
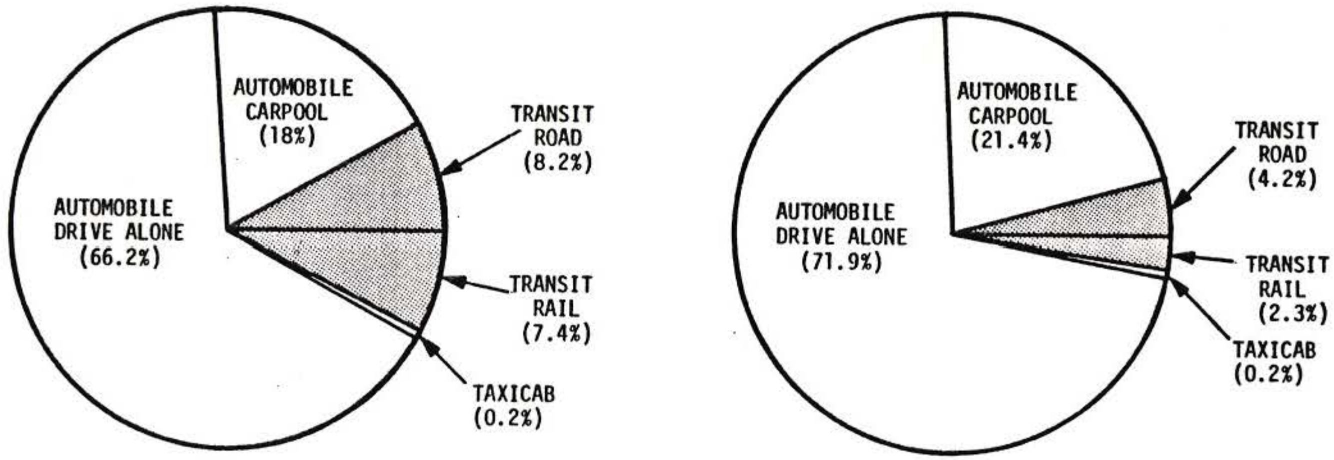


FIGURE 2-1. TRANSIT RELATIONSHIP - 1965-1979



(a)

BASED ON A SAMPLE FROM 41 SMSA's AS SHOWN IN REFS. 2 & 3.

(b)

BASED ON A SAMPLE FROM ALL SMSA's AS SHOWN IN REF. 4

FIGURE 2-2. MODE OF TRAVEL TO WORK - 1975 namely, the automobile which accounts for some 84 to 93 percent of work trips and an even greater percentage of nonwork trips. The likelihood of the shift to transit from automobile will be further enhanced as gasoline prices continue to climb, pertroleum import quotas are maintained, and gasoline rationing is instituted.

It is also possible to examine the urban travel market in terms of place of residence and place of work. As shown in Figure 2-3, with the exception of central city to central city, only a very small percentage of the work trips, especially those between suburbs, are captured by transit. Of the work trips made entirely within central cities, transit captures about 18 percent which is equivalent to about 5.7 percent of all urban work trips, whereas transit captures only 2 percent of the work trips between suburbs, or 0.7 percent of all urban work trips.

2.2 VEHICLE FLEET

It is reported that there are approximately 52,000 transit buses of various sizes in the nation's fleet and another 600 or so trolley coaches. Figure 2-4 shows how the fleet sizes have varied over the years. The sharp increase in motor buses fleet size coincides with the 1973 oil embargo -- after accounting for a year or so delay between the time of the decision to buy and the time of delivery. For the most part, the motor bus fleet is composed of standard size (35 to 40 foot) transit coaches. Figure 2-5 shows the distribution according to vehicle size. Large buses include double-deck and articulated vehicles, while small buses include coaches up to 30 feet long but exclude vans. Data on vans was not available.

It is worth noting the small discrepancy in 1978 bus fleet sizes as estimated by the American Public Transit Association (APTA) (52,000) and by the Urban Mass Transportation Administration (UMTA) Office of Transit Assistance (49,910). These estimates are used as guidelines only in this report and do not affect the conclusions. The reason for the discrepancy is not totally clear at this time.

The age of the transit bus fleet is also of interest here. As shown in Figure 2-6, about half the fleet of standard size buses is less than 7.5 years old. Approximately 2500 buses are 19 years old or older. If annual

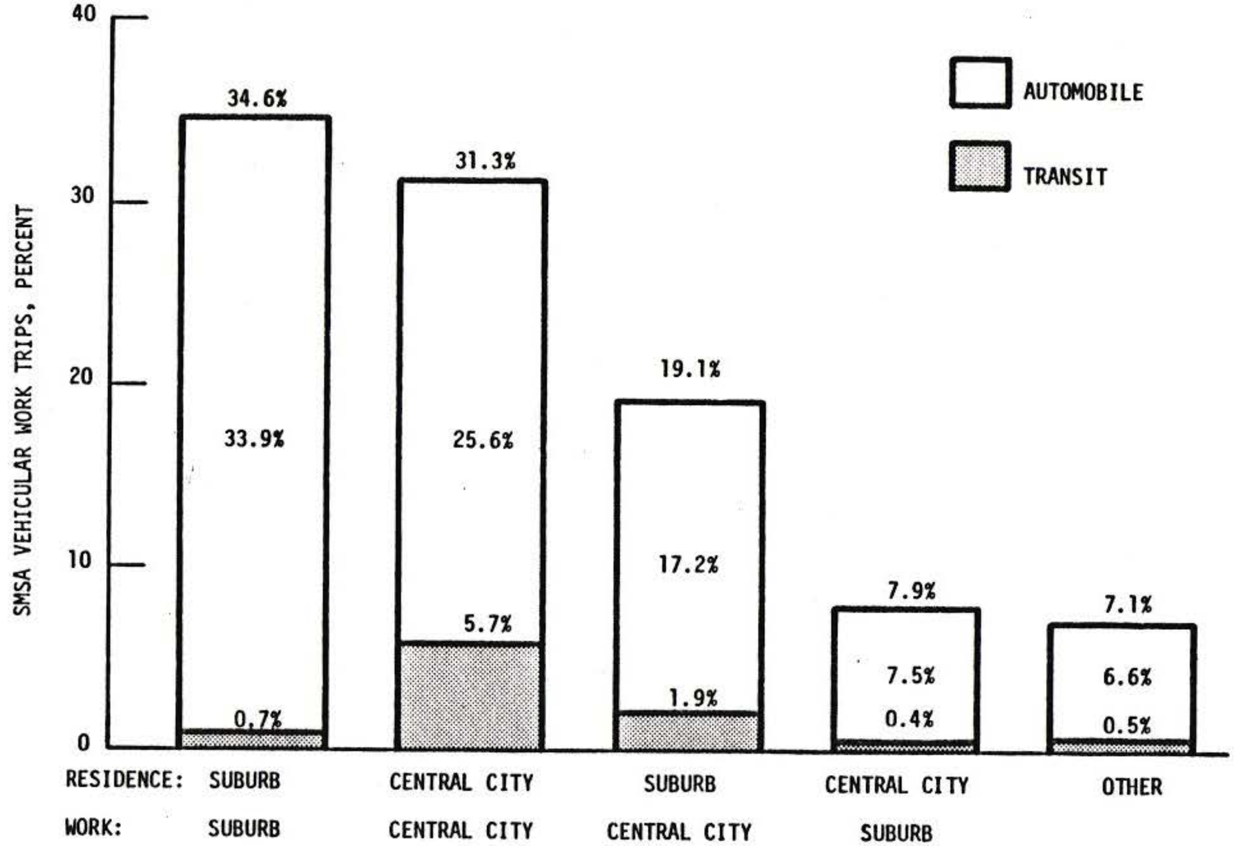


FIGURE 2-3. MEANS OF TRANSPORTATION TO WORK BY PLACE OF RESIDENCE AND PLACE OF WORK

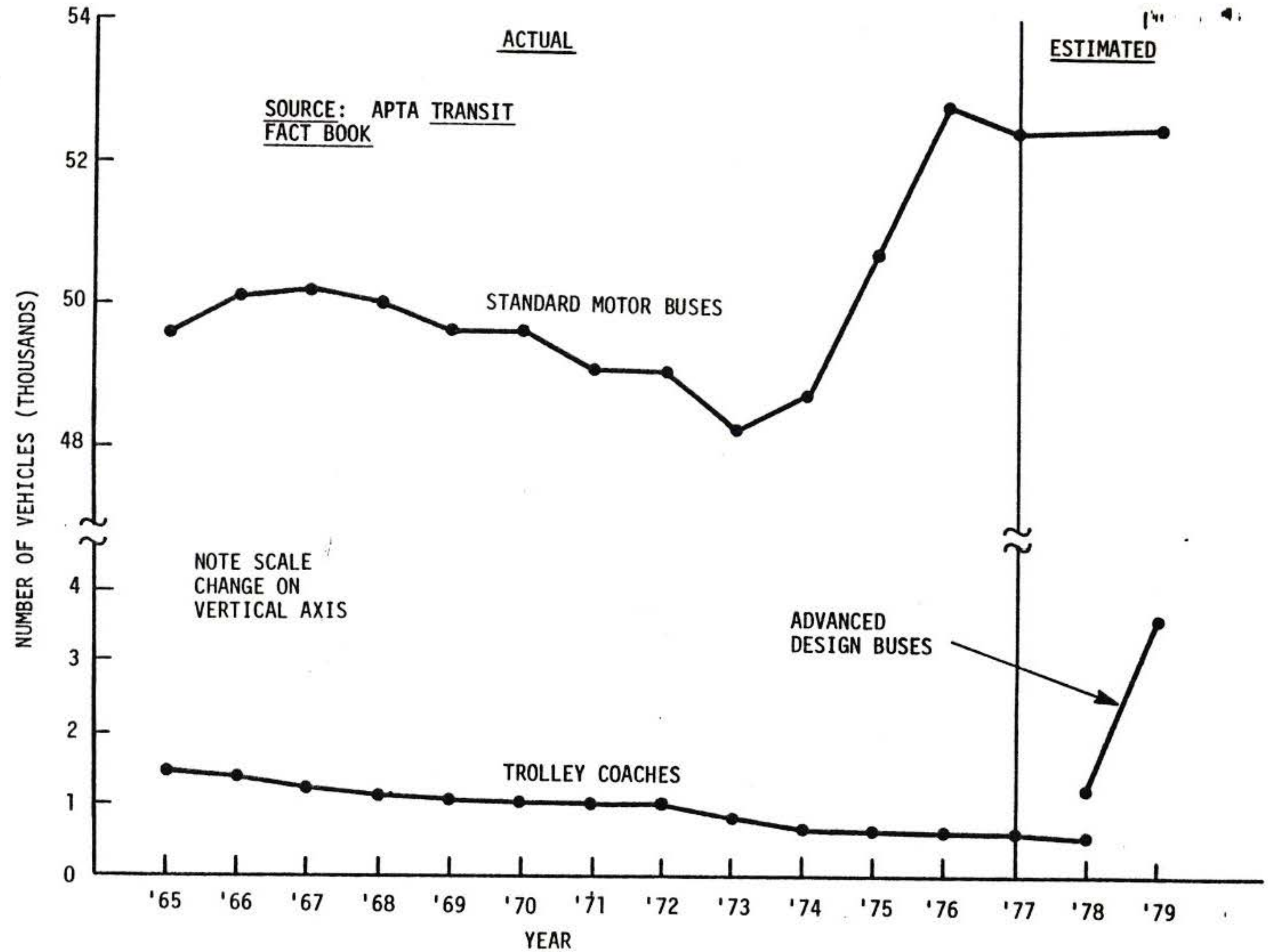
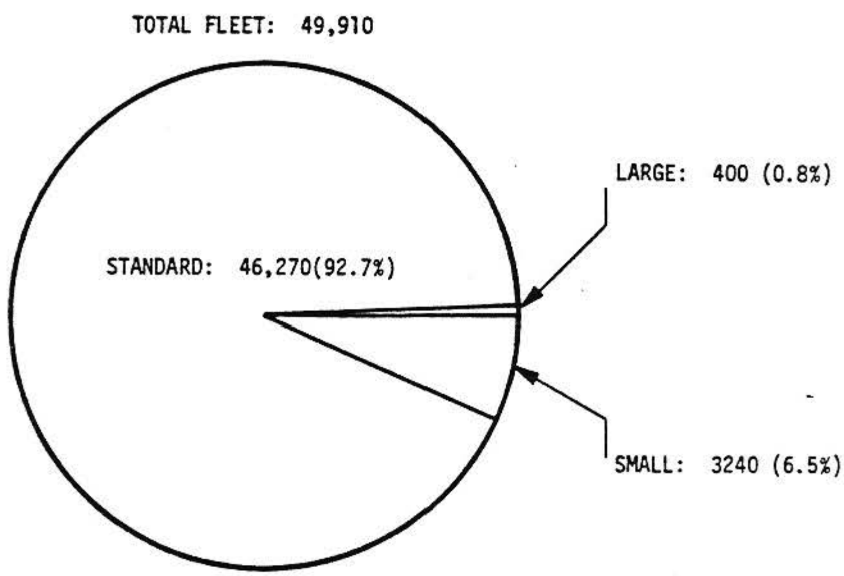


FIGURE 2-4. U.S. ROAD TRANSIT FLEET - 1965-1979



SOURCES: STANDARD AND SMALL BUS FLEET VALUES ARE FROM OFFICE OF TRANSIT ASSISTANCE FLEET INVENTORY AS DETERMINED FROM BOOZ-ALLEN COMPUTER FILE. LARGE BUS FLEET VALUE IS FROM OFFICE OF TRANSIT ASSISTANCE CAPITAL GRANT RECORDS.

FIGURE 2-5. U.S. MOTOR FLEET BY SIZE CLASS - 1978 bus retirements were restricted to retiring only the oldest vehicles in the fleet, then it appears that a new vehicle delivery rate of about 2300 to 2400 vehicles per year will sustain the fleet at its present level for approximately 10 years. Available data from transit authorities indicate that of all the standard size buses in the fleet, only about 81 percent of 37,500 to 40,500 are used to meet peak-hour demand. There is, therefore, a reserve capacity of 8300 to 9500 vehicles. While this statement is probably true, in all likelihood it overstates the reserve peak-hour carrying capacity, since most buses held in reserve are older buses which might not hold up well if pressed into daily service.

In recent years, the procurement rate, and correspondingly the delivery rate, of standard size buses has been erratic. As shown in Figure 2-7, about 2700 buses were delivered in 1966; 1300 in 1970; 4700 in 1975; and 1800 in 1977. With the advent of the Advanced Design Bus and the significant backlog of orders, the delivery rate can be expected to smooth out considerably. In contrast, the small bus delivery rate has been considerably lower and smoother, and it has increased significantly over time. In 1965, slightly more than 200 small buses were delivered; by 1978, the rate had climbed more than 500 percent as some 1100 small buses were delivered.

2.3 SERVICE

In 1965, the fleet of 49,600 buses generated some 1.53 billion vehicle-miles of service -- about 30,000 vehicle-miles per vehicle-year. From that time through 1972, fleet size dropped slightly (about 1 percent), but fleet vehicle-miles dropped more than 14 percent and vehicle-miles per vehicle-year dropped more than 13 percent. The amount of bus transit service offered to the public was decreasing significantly. In 1973 the trend was reversed. By 1977 fleet size had increased by about 6 percent, but fleet vehicle-miles had increased almost 17 percent. Figure 2-8 shows the trend in this latter indicator. Projecting the trend suggests that it will reach 35,000 miles per year by 1980.

Figure 2.8 also shows the same indicator for trolley coaches. Up until 1973, trolley coaches were utilized at about the same rate as buses -- approximately 30,000 vehicle-miles per vehicle-year. Since that time, utilization

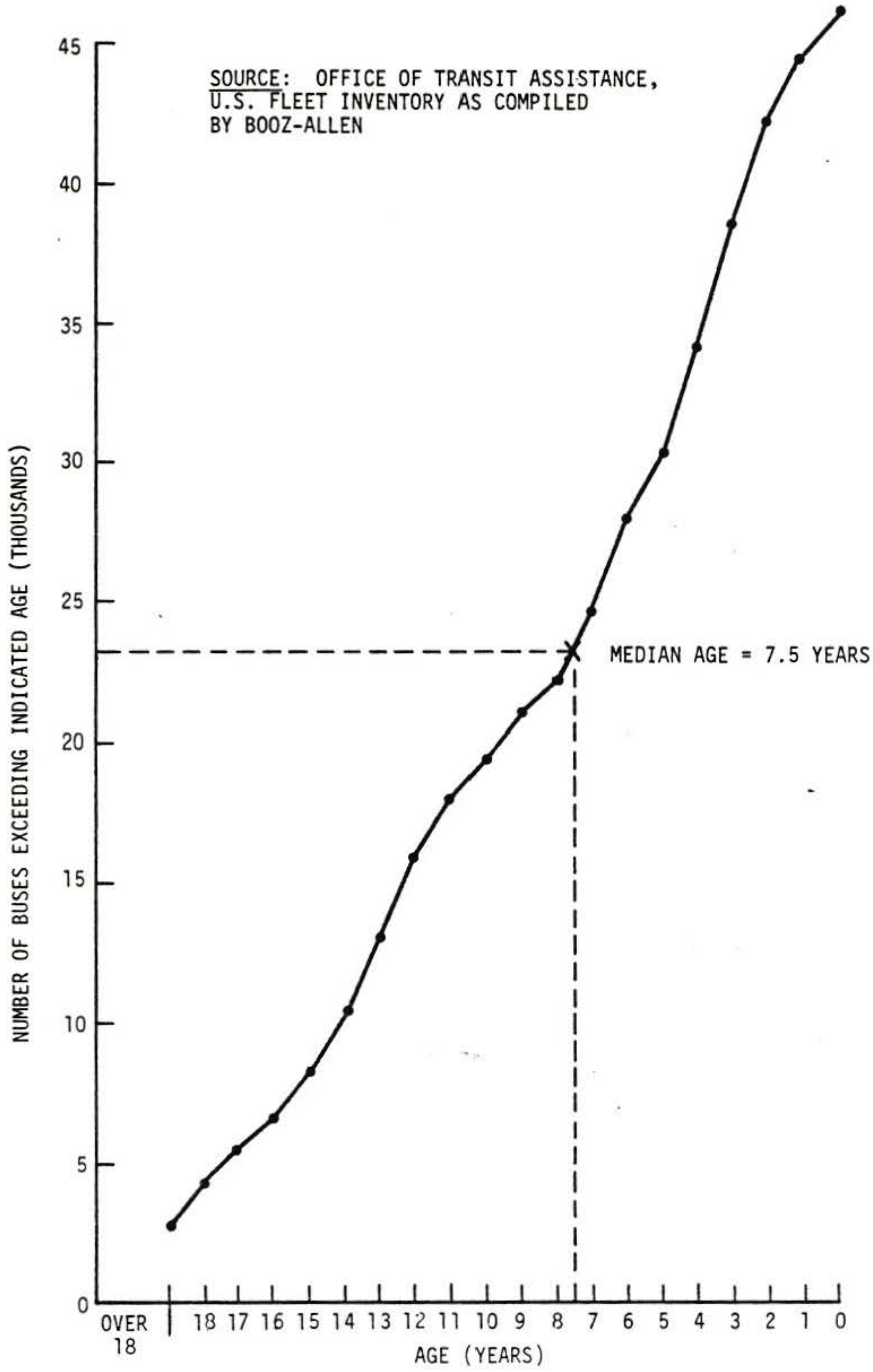


FIGURE 2-6. CUMULATIVE AGE DISTRIBUTION OF U.S. STANDARD SIZE TRANSIT BUS FLEET - 1978

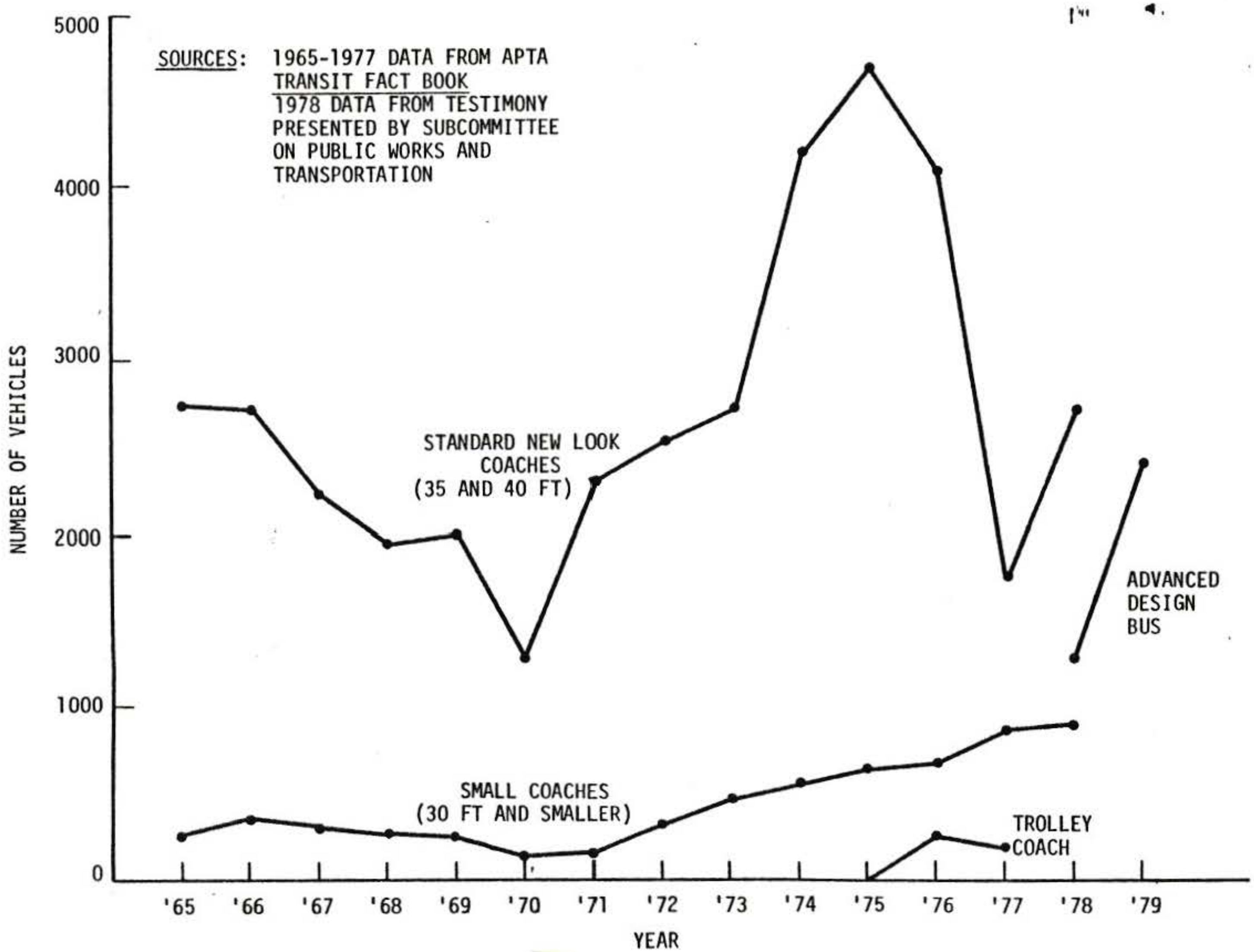


FIGURE 2-7. ROAD TRANSIT VEHICLES DELIVERED - 1965-1978

SOURCE: APTA TRANSIT FACT BOOK

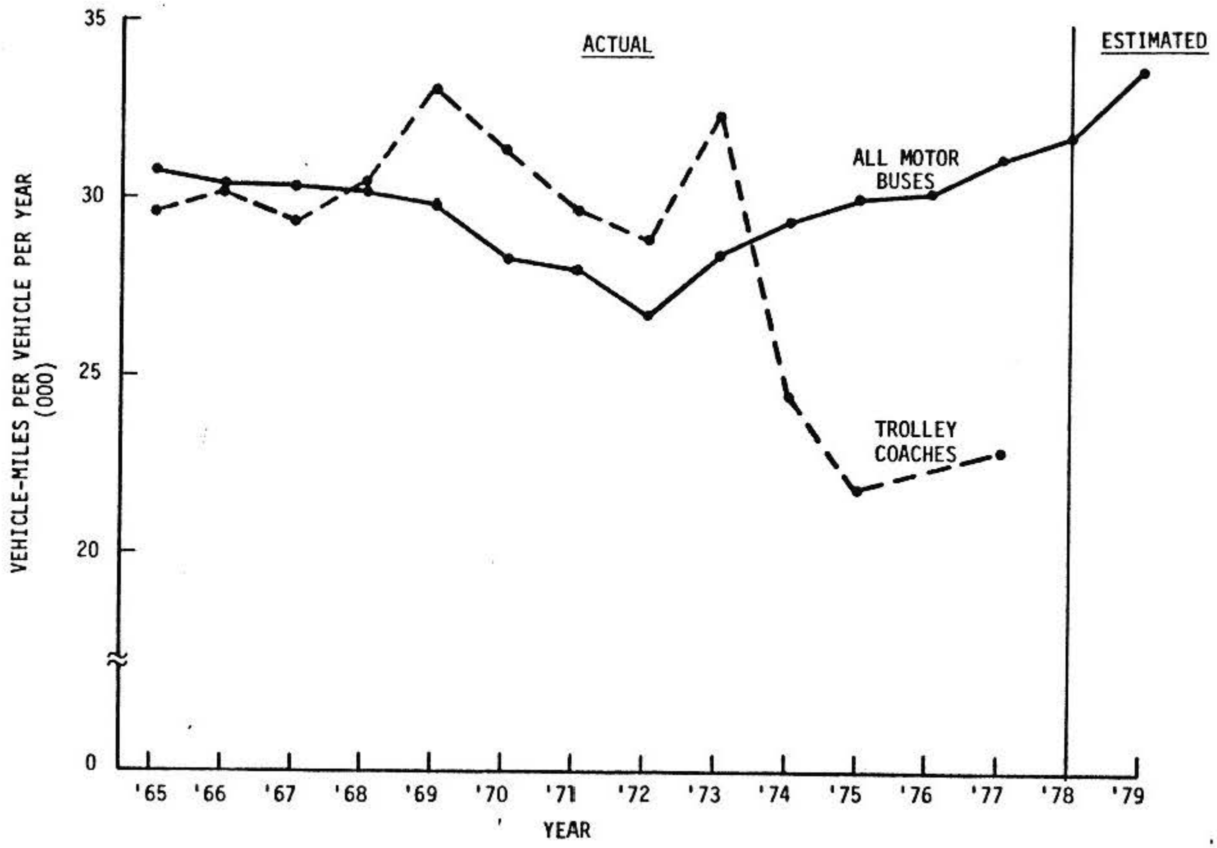


FIGURE 2-8. ROAD TRANSIT VEHICLE UTILIZATION - 1965-1979

has dropped to the 22,000 range. The reasons for this decrease are unclear and clearly require additional detailed analysis.

2.4 FUNDING

Governmental expenditures in support of transit have increased markedly in recent years. But has the increase been in real terms, or has it just kept pace with inflation? An examination of the trends in capital and operating assistance in terms of constant and actual dollars is therefore informative.

To better understand the funding trends, however, it is worthwhile to first examine trends in bus prices and in bus operating costs. Figure 2-9 shows the trend in the price of a standard bus. Not only has the price been increasing in actual dollars, about 250 percent in the last 10 years, but it has been markedly outpacing inflation by about 73 percent over the last 10 years.*

It should be emphasized that Figure 2-9 indicates the trend in average costs of new standard size city coaches. Typically, prices vary greatly. For example, the MBTA received bids of $86,600** per vehicle and Denver RTA opened bids of $133,000 per vehicle (New Look design in both cases).*** The range in price is based on the special items such as air conditioning, new V6-92 turbocharged diesel engine, kneeler, wheelchair lifts, and a $2500 paint job, requested by Denver compared to the standard vehicle specified by the MBTA.

Two important points should be raised concerning this information. Although transit properties are required by state and local law to specify nonstandard items in their vehicle procurement specifications, additional nonstandard features are encouraged since the additional cost is 80 percent subsidized by the Federal Government. The procurement of more "standard" city coaches at more economical prices can occur through a reassement and reduction of local regulations and transit operator cooperation.

*In this and subsequent analyses, the Gross National Product (GNP) price deflator is used as the inflation indicator.
**January, 1979.
***January, 1980.

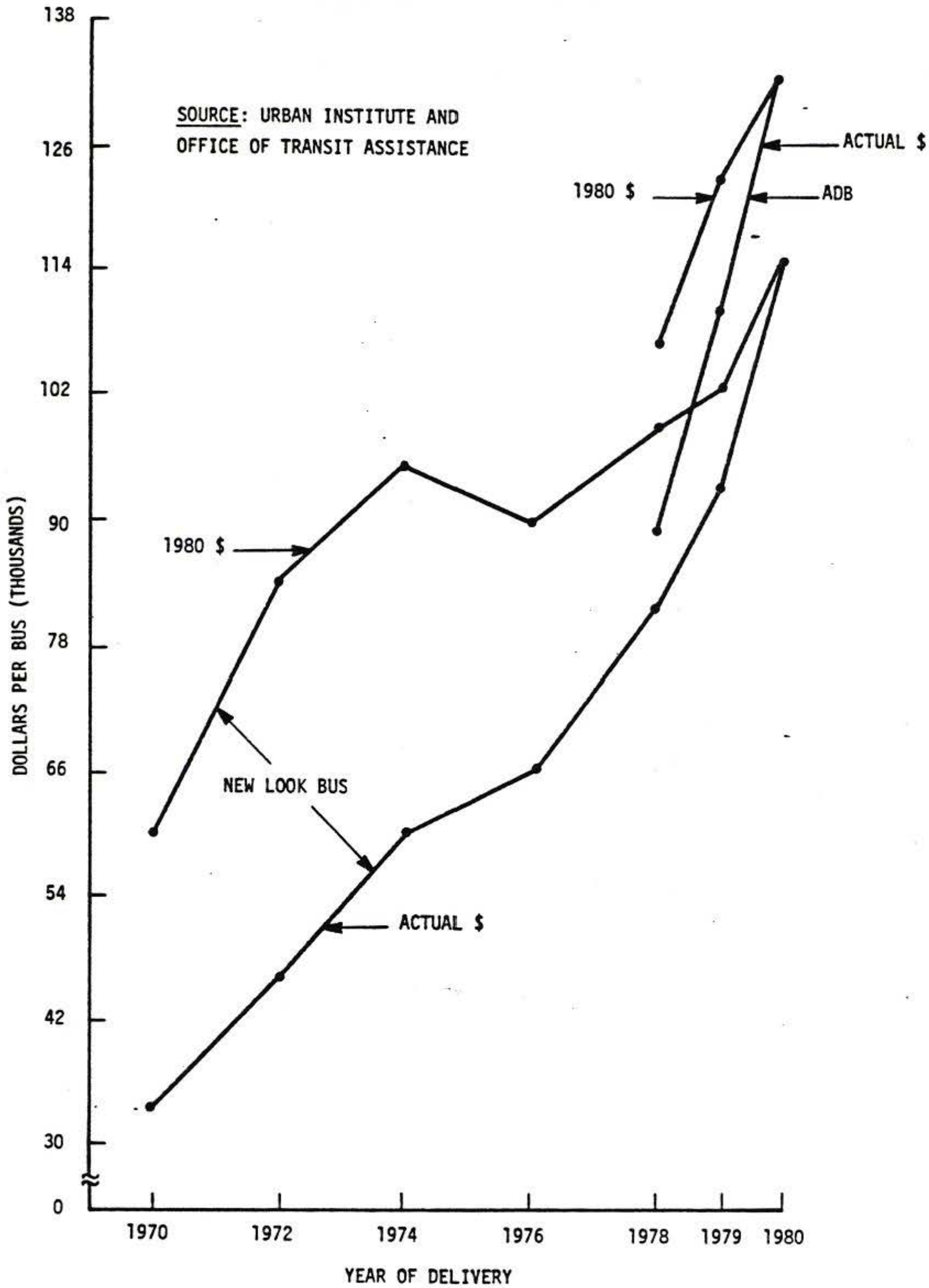


FIGURE 2-9. AVERAGE UNIT COST FOR STANDARD BUS - 1970-1980

Secondly, it should be recognized that because of UMTA's capital and operating assistance, the Federal Government is subsidizing private industry research and development. In addition, local properties are providing excellent proving grounds for new product development. A case in point is the V6-92 turbo-charged engine which is heavily promoted by GM sales representatives. UMTA grant money pays for 80 percent of the initial cost and 50 percent of maintenance costs not reimbursed by GM under warranty provisions.

Although the preceding facts apply only to New Look buses, the same general conclusion applies to Advanced Design Buses (ADBs). Figure 2-9 also shows ADB price trends.

In contrast to bus prices, bus operating costs appear to have increased only slightly faster than inflation in recent years. Figure 2-10 shows bus operating costs measured in actual dollars obtained from two sources. The figures are significantly different because one is a median of a 50 property sample, and the other is an "average" obtained by dividing total industry operating expenses (less depreciation) by total vehicle miles.* Looking at the data in constant dollars reveals an increase of only 7 percent over the 1970-1975 period, and a slight decrease of 2.5 percent over the 1975-1977 period. Overall, it looks as though operating costs have increased only 4.4 percent in real terms from 1970 to 1977. This is equivalent to about 0.52 percent per year, compounded.

Turning to governmental capital assistance (see Figure 2-11) it appears that the increases in recent years have been quite modest in real terms. Federal capital assistance has increased about 2.5 percent over the 1975-1979 period, while local capital assistance has just about kept pace with inflation.

The Federal share is in the vicinity of $600 million (1980 dollars), while the local share is about $150 million.

While capital assistance has not grown significantly in recent years, operating assistance has. This, of course, reflects the sharp increase in total fleet vehicle-miles, as well as the drop in vehicle productivity over

*If the latter procedure had been applied to the 50 property sample, the data would show far better agreement. The data were not readily available to perform such a calculation.

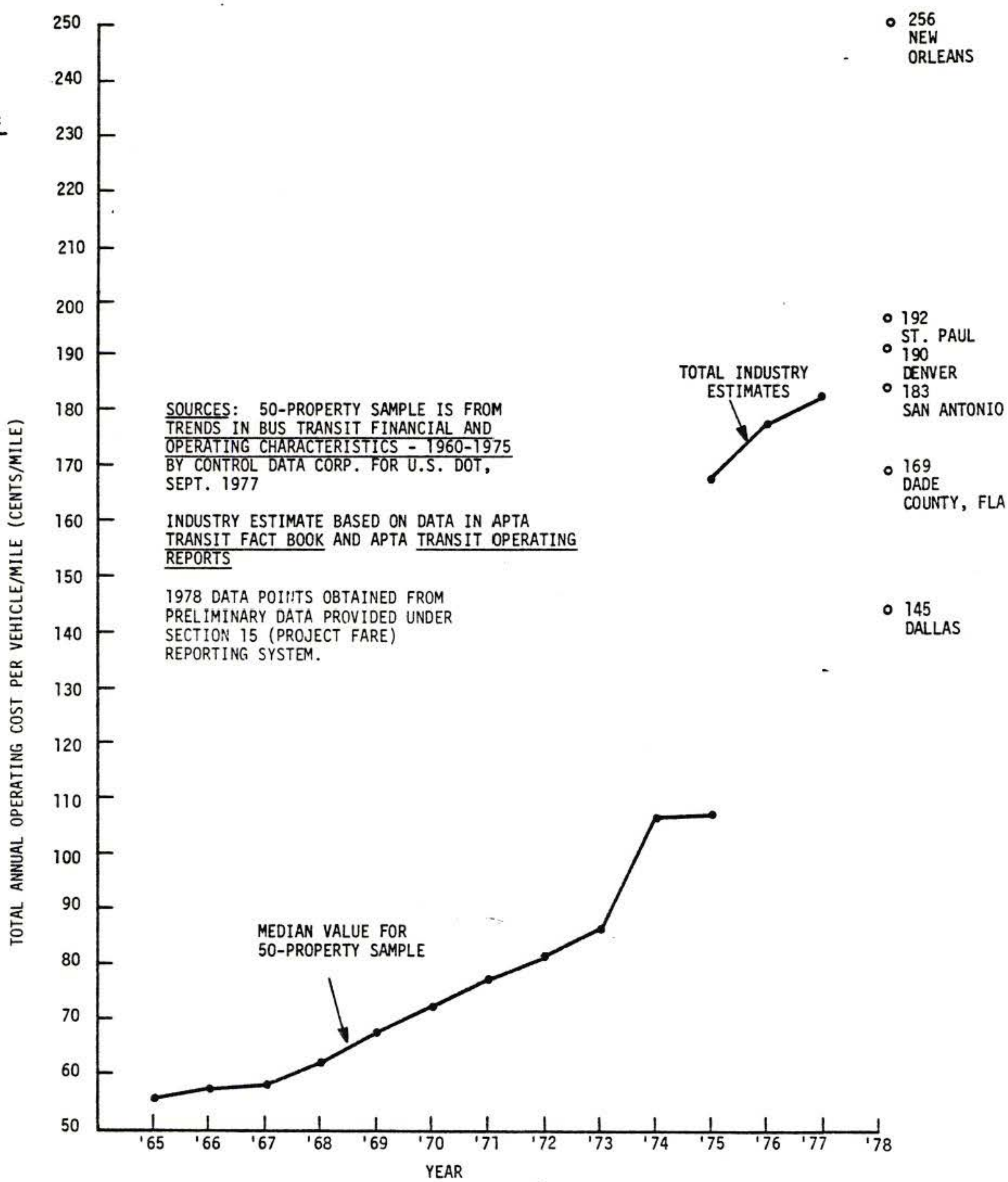


FIGURE 2-10. ANNUAL OPERATING COST PER VEHICLE-MILE (LESS DEPRECIATION) - 1965-1977

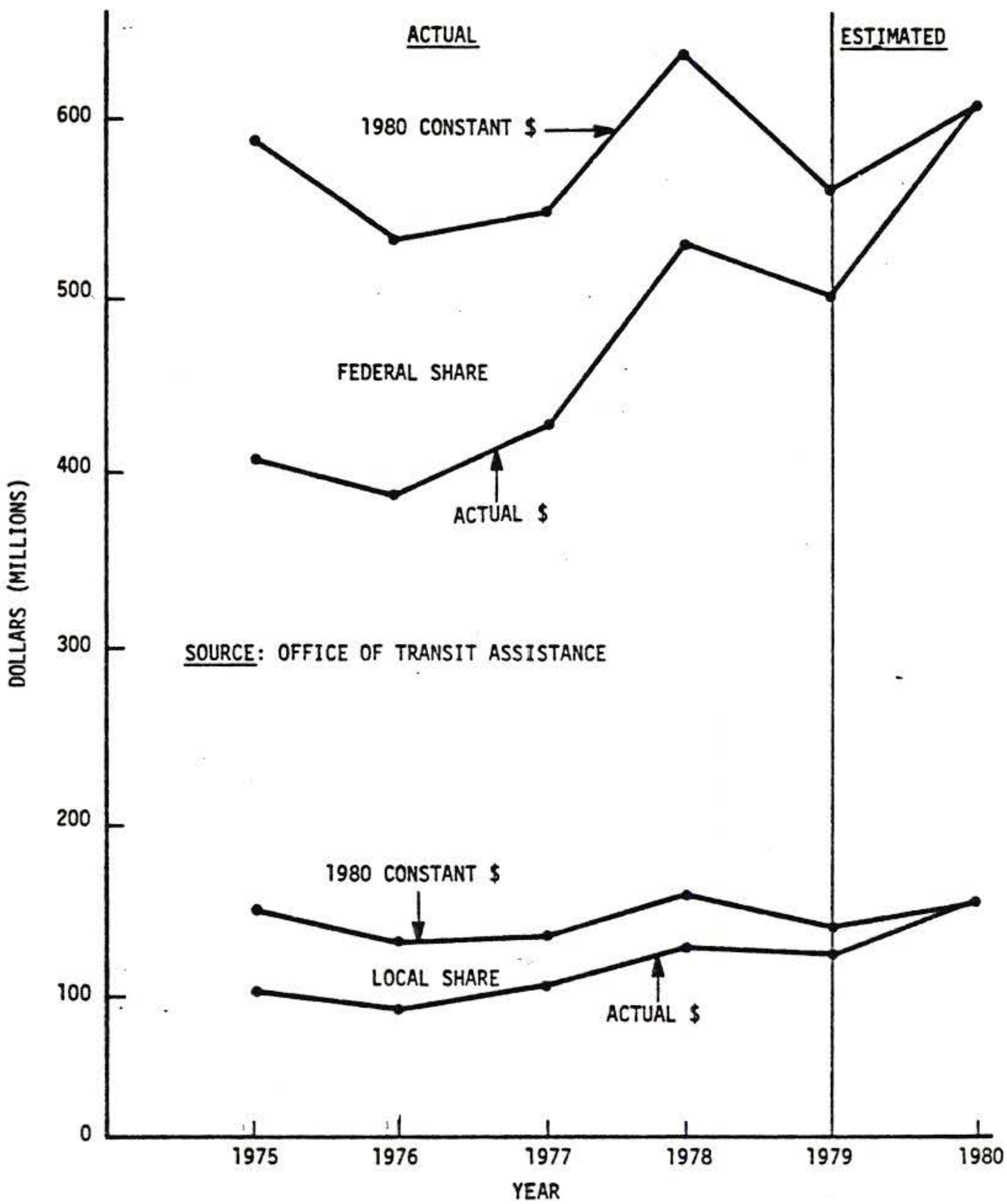


FIGURE 2-11. MOTOR BUS CAPITAL ASSISTANCE - 1975-1980

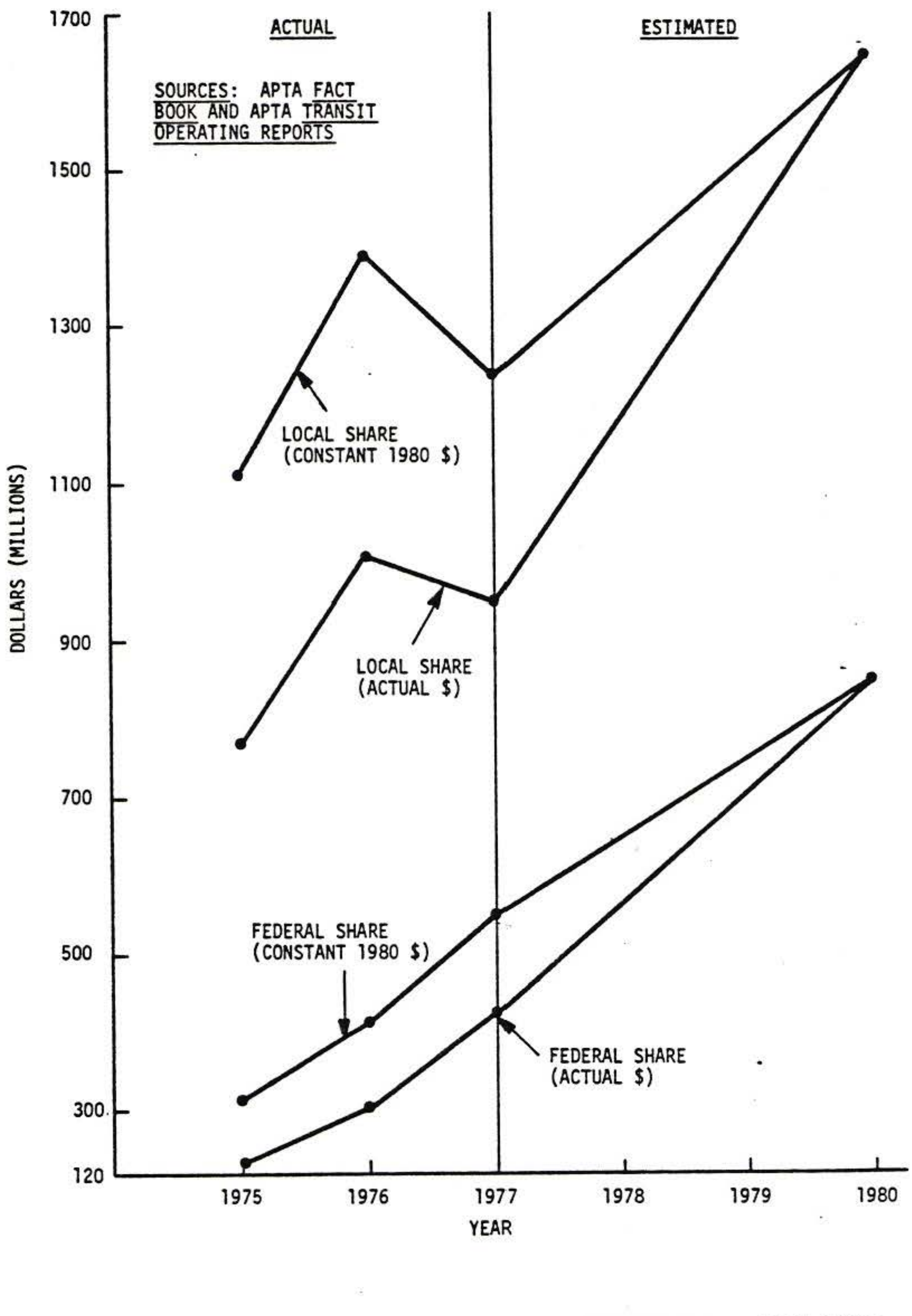


FIGURE 2-12. MOTOR BUS OPERATING ASSISTANCE - 1975-1980

the same period. Figure 2-12 shows the trends for bus service. By 1980, the local share is projected to reach $1.65 billion, while the Federal share is expected to reach $0.85 billion. Both are outpacing inflation by a wide margin, but only because of the sharp increase in the amount of service offered (measured in vehicle-miles).

2.5 SUPPLY INDUSTRY

This section addresses production capacity, manufacturing characteristics, and financial considerations of the domestic transit bus manufacturers. The perspective of this analysis is "business strategic" in the sense that an attempt has been made to place the transit bus product in the context of overall corporate strategy. By examining the bus manufacturing industry in this way, it is possible to illustrate how changes in transit buses relate to broad industrial issues.

2.5.1 Characteristics of the Industry

Table 2-1 lists the major manufacturers of urban transit vehicles. It is significant to note that bus manufacturing is not a distinct industry but is an offshoot of the much larger truck and heavy equipment industry. The lower strategic power of bus manufacture can be seen by comparing the relative size of truck and bus fleets in the U.S. In 1977, the following new vehicle registrations were made in the U.S.:

public buses	8,285
trucks	1,800,000
medium and heavy trucks	700,000

Public bus registrations were approximately 0.4 percent of the total truck market size. Similarly, in the same year there were a total of 249,000 buses registered compared with 29,000,000 trucks. These volume differences are critical to analysis of bus manufacturing because they indicate the relatively low market strength of buses, the high cost requirements for each bus, and the manufacturing techniques which must be employed to make industrial units in such low volume. Specifically, low bus volumes limit the manufacturers to labor-intensive processes or common use of truck parts in buses. Therefore, manufacturers cannot use economies of scale, such as those found in higher volume truck and automobile production. The economics of low

TABLE 2-1. REPRESENTATIVE URBAN TRANSIT VEHICLES

	MANUFACTURERS	VEHICLE SIZE
Hfgh Capacity	AM General (M.A.N.; W. Germany)	Articulated 54', 65 passenger
	Crown Coach (Ikarus; Hungary)	55' or 60', 71 passenger
	Gillig-Neoplan (License from Gottlieb Auwarter, KG; Stuttgart Germany)	Double decker
	British Leyland Titan	Double decker; 31'; 73 passenger
Standard	AM General	Trolleybus 40'6", 46 passenger
"New Look"	GM Canada	35', 45 passenger 40', 51 passenger
	Flyer Industries (Canada)	Trolleybus 40', 51 passenger Bus 40', 39 or 47 passenger
"ADB"	GM	RTS 2, 35', 39 or 47 passenger 40', 39 or 47 passenger
	Grumman Flxible	#870, 35', 40 passenger 40', 48 passenger
Small	Greyhound (TMC)	30'8", 32 passenger
	Gillig	30'11", 30-35 passenger
	Flyer Industries	31', 32 passenger
	Blue Bird	30', 31 passenger
	Argosy/Airstream	28', 29 passenger
	Carpenter	29'-39', 36-56 passenger
	Atlantic Research	24'-28', 29 passenger

volume production require that the bus be a collection of custom-built, labor-intensive components, with several key components derived from higher volume production runs geared primarily toward trucks. Producers using high capital automated techniques will not often be attracted to bus production unless they can use portions of common parts already fitted to trucks and can be certain of orders.

These basic industrial conditions lead to the conclusion that "production capacity" in the bus industry is not a unique or discrete measurement. Rather, capacity is defined as the varied ability of companies to assemble individual components, each of which could represent a production limit, depending upon the nature of the company and the ability of suppliers to procure parts. Capacity can be a function of the line speed in an automated assembly plant, the ability to produce critical components such as engines and transmissions, or the ability to train labor in a specific metropolitan area. Production capacity can also be a function of the degree of change specified in bus design. Small changes may not affect capacity, but larger changes or changes in critical components can have severe impacts on ability to deliver buses. Production capacity for new design buses can also be viewed as a function of the compatibility of that design with the future design of trucks, from which components and techniques will be drawn.

One thing is certain and homogeneous for all components -- effective capacity is almost totally a function of perceived long-term demand for buses. Decisions to invest in new increments of production cannot be made on short-term promises of unit demand and, therefore, the most critical determinants of long-term bus capacity will be <u>volume</u> of demand, <u>duration</u> of demand, and the <u>certainty</u> of these factors. A one-year doubling of demand is not likely to produce a doubling in bus capacity, whereas a five-year doubling of demand, if perceived as real, will almost certainly stimulate new capacity.

Increments of demand will also force stages of capacity decision-making which will change according to the new circumstances faced by each manufacturer. For example, a decision to expand production capacity by training a second shift of workers is vastly different from a decision on capacity expansion by investing in new fixed assets (machines or buildings). Of all the road transit vehicle manufacturers in the United States, only Grumman (Flxible) and General Motors (GM) use the traditional assembly line techniques. In comparison to truck assembly, it is almost a misnomer to classify these production facilities as assembly lines because despite their line configurations, most of the work is performed without the job separation of the truck or auto line. However, in comparison to other vehicle manufacturers, these two larger producers can be viewed as automated. The other manufacturers, including those for small transit buses, are known as "Job Shop" assemblers. They produce vehicles in a very different manner. Parts are brought to one spot on the factory floor, and the bus is assembled in that spot from the ground up. Obviously, variations in this process are to be found, but the general spatial, nonautomated concept holds. These companies face very different decisions in expanding. In a simplistic sense, their decision to expand only requires more floor space for assembly and more trained labor to assemble parts. Shift work is entirely possible, although the process flows will not be in a line format.

2.5.2 Advanced Design Bus (ADB) Manufacturers

a. General Motors

GM began producing the ADB in its new facilities located in Pontiac, Michigan in 1977. The GM version of the ADB appears designed for a long life-cycle, perhaps 10 to 20 years, if the history of the new look vehicle is any precedent. GM also produces a number of other bus subsystems, most notably the engines and transmissions which are used in most of the U.S. transit buses produced by all companies.

The maximum capacity per 8 hour shift at GM is 8 vehicles. The company is currently operating on two 8 hour shifts. The maximum capacity with existing plant is between 5000 to 6000 vehicles per year. The company indicates that expanding to additional increased operations may produce temporary constraints owing to supplier investment lead times. However, they also suggest that such limitations would be largely temporary if demand were certain.

b. Grumman Flxible

Grumman produces an advanced design bus in semi-automated assembly facilities located in Delaware, Ohio. The nature of Flxible's assembly process is similar to that of GM, although Grumman uses different materials (aluminum body) and a different job design. Grumman also does not have to contend with investment decisions on engine and transmission transfer lines, but it presumably loses some flexibility because of this.

At the moment, Grumman has moved to an imbalanced two-shift operation. The combined shift output at present for this company is 8 units per day, although the maximum capacity per an 8 hour shift is 8 vehicles, similar to GM. Also like GM, the capacity is theoretically limited only by the cycle time of operation. However, maximum capacity is more difficult to quantify for Grumman, primarily because of the slower startup of shifts this company has experienced. They have already proven the likelihood of second shift operations, and if they can bring line speeds up to GM levels, this should yield 4000 units per year for 2 shifts and 5000 to 6000 units per year for 3 shifts.

2.5.3 "New Look" Related Bus Manufacturers

At present, there are only two manufacturers of "New Look" buses and both of them are in Canada.

a. Flyer Industries

Flyer Industries of Canada assembles a form of the older "New Look" bus design, which can be shipped to both Canadian and U.S. markets. The process is labor-intensive. The company indicates that about 85 percent of component parts are purchased from U.S. companies, and it is assumed that these are standard manufacture from the older GM-type bus component manufacturers.

The company indicates they are generally running 1 shift, producing 2 buses per shift, for an annual output of approximately 500 buses, and can move quickly to a second shift, bringing output to 1000 buses per year. They have also indicated that if demand is high enough for long enough, they could add new factory space in 6 months to a year from the time of decision, thereby bringing even more output on line. Major constraint to expansion appears to be the uncertainty of access to the U.S. market. Considerations such as potential "buy American" criteria or changing design specifications were cited as mitigating against access to increasing vehicle demand in the U.S.

b. GM Canada

This subsidiary of GM makes a "New Look" bus design using older tooling transferred from the United States operations upon conversion to ADB. It does not use the more highly automated techniques of the present U.S. facility. Labor intensity is higher, and assembly is more like a job shop. Engines and transmissions are from the other company divisions, and outside suppliers are the standard ones.

GM Canada currently uses one-shift operations, producing 3 units per day. The company indicates that it can move to a production of 7 units per day or 1750 per year, before it runs into capital equipment constraints.

2.5.4 Trolley Bus and Large Capacity Transit Bus Manufacturers

AM General

AM General currently has capacity to make two types of transit vehicles: a diesel bus and an electric trolley bus version of this design. AM has been finishing large capacity articulated bus units delivered (in running condition) from M.A.N. in Europe. The company indicates that these orders have been filled and that M.A.N. has chosen to end the association, owing most likely to uncertainty over funding and therefore demand of these units in the future.

AM's capacity is essentially comprised of tooling it invested several years ago, which became underutilized through reduced market for this type of bus. Tooling has been transferred from Mishawaka, Indiana, to Marshall, Texas.

AM's older bus facility has been tooled up to produce 10 units per day before orders fell off for this type of bus. Once the tooling was moved to Texas, the capacity was reduced to make 1-2 units of electric, or 2-3 units of diesel buses, per day. This suggests AM could currently build 500-750 of its diesel design buses per year.

AM indicates it could annex its Texas plant floor space and redeploy the tooling configurations used in its earlier bus plant to reachieve the capacity of 10 units of the older design bus per day. This could yield 2500 buses per year at 2 shift levels. Therefore, the most immediate capacity constraint is floor space.

However, more significant than the floor space constaint, which could be solved within one year lead time, is the uncertainty of funding and bus orders for this type of product. AM invested heavily in capacity before and orders dropped off, so the decision to return to a similar capacity is not likely to be made.

2.3.5 "Small Bus"

General

There are a few small city buses on the market. They are close to 30 feet in length, carry up to 30 passengers and are of "integrated" construction, this meaning that they are built as a body-frame-drive train bus ---- not a body put onto a truck chassis.

Their attractiveness to transit properties lies in fuel efficiency, maneuverability, lighter weight and smaller price than the 35 or 40 foot bus.

Most small bus manufacturing tends to be low volume (200 to 500) and labor intensive, oriented to low production procedures and not heavily committed in tooling or fixtures.

The principal manufacturers of this class of vehicle are Blue Bird, Gillig/Neoplan (California), Transportation Mfg. Corp. (New Mexico), Chance Mfg. (Kansas), and Skillcraft (Florida). The latter has recently introduced a low floor (18 inch) bus in this category.

a. Blue Bird

Blue Bird produces primarily small, heavy duty transit buses which appear to have more specialized transit applications. Producers in this segment may be affected differently by bus funding issues, and the company reiterates this problem in relationship to its product. Blue Bird currently produces at 2 units per week, or approximately 100 buses per year. It is assumed that this is demand-constrained because the process appears quite labor-intensive. It can be assumed that Blue Bird can expand floor space and labor is consort with demand increases without large capital decisions.

b. Transportation Manufacturing Corp. (TMC)

TMC has recently entered the transit bus industry as a derivative of intercity bus manufacture. The prime product is the Citycruiser, a small heavy duty transit bus based on the Orion bus produced by Ontario Bus Industries. This is assumed to be comparable to and competitive with the Blue Bird design.

TMC's operation, from preliminary research, is definitely not a full-line operation, but a single-station layout. Given the labor intensity and flexibility of this type of operation, maximum capacity is "infinite" and constrained primarily by demand and component supply. As with the other labor-intensive producers, physical expansion appears easily achieved within short periods, although parts supplies are not assured. It appears that these small bus producers have lower negotiating leverage with parts suppliers as compared to Grumman or GM, primarily because their market segments appear to be of even lower volume than the larger transit buses, and because funding is less certain.

c. Chance Manufacturing Co

Chance manufactures the 25-foot, 25-passenger RT 50 which is a heavy duty coach with many of the components of the standard large urban bus.

Chance purchased the design, rights, work in progress and tools of Minibus from MCA of California. With design changes to the coach they are now adding the AMTV, 30-passenger trailer module to their product line. Coach production, now averaged at two per week, and is expected to be three per week in 1981. The first trailer module designed for city transit use was delivered to Wicheta, June 4, 1980. Capacity for the AMTV is yet unknown.

d. Skillcraft Industries

This manufacturer has recently introduced a low floor 31-foot, 31-passenger integrated bus using UMTA's Small Bus draft specification. Their previous activity has centered on motor homes, lifts and conversion bodies.

A model of thier "L.R." model bus is beginning evaluation in transit use for Sarasota, Florida. This new vehicle production capacity and market demand are still unknown.

e. Other Markers

There are other companies engaged in the delivery of transit equipment to the U.S. markets. However, not much data are available at this time.

2.5.6 Vehicle Refurbishment

The combined capacity of transit operators and rebuild contractors is probably somewhere between 500 and 1000 units per year. Potential capacity could be almost twice that given adequate facilities, equipment, manpower, and parts procurement sources. Transit operators are expected to have the largest share of total industry capacity for bus rebuilding. There are only a handful of private contractors specializing in vehicle rebuilding. Most of these are body shops or bus builders. A more detailed discussion of the bus refurbishment industry is given in Appendix E.

2.5.7 Subsystem Manufacturers' Capabilities

a. Engine Subsystem

Transit bus engines are basically derived from truck engines with modifications, including the production of maximum horsepower at 2100 rpm, left hand rotation, inclined mounting, and other geared accessory drives. They enjoy an important cost advantage of sharing a high-volume medium and heavy duty truck market. The principal subsystem characteristics sought in transit bus applications are reliability, durability, low engine specific fuel consumption, low weight, and responsive acceleration torque characteristics. V-configuration is most desirable to meet the maintainability requirements.

Major manufacturers of diesel engines for medium and heavy trucks and buses are Detroit Diesel Allison Division of General Motors (DDAD), the Cummins Engine Company, and the Caterpillar Tractor Company. DDAD obtained over 90 percent of bus engine sales during the decade of the 60s and 70s with the 6V71N and 8V71N engines.

With the advent of new performance standards for the Advanced Design Bus, in combination with more stringent emission standards and emphasis on petroleum and fuel economy, DDAD has recently introduced a new 6V92T engine as an intended replacement for the 8V71. This provides an opportunity for other manufacturers to enter the transit bus engine competition on more even terms, because purchasers of new buses with either the new DDAD model or any new brand must acquire an inventory of new tools and spare parts for service and maintenance. Equally important to prospective new engine suppliers is the potential growth of the transit bus market. Cummins Engine Company recognizes this and is acting upon this new market opportunity by offering its VTB-903 engine in combination with the DDAD/GMC V-730 transmission for transit bus service. Pilot installations are operating in Grumman Flxible buses in a half dozen cities throughout the U.S. Production quantities of this engine are being supplied to Flyer for the New Look buses. Caterpillar, a manufacturer of truck engines, lacks a basic V-configuration diesel engine for transit buses. Therefore, at present, there are only two major domestic engine manufacturers for the standard size city coach.

In transit applications, DDAD produced a total of 4600 units of 6V71N and 8V71N engines and 50 units of 6V92T engines in 1978. One-hundred VTB-903 units were produced by Cummins for the transit market in 1978. The production has been geared to the demand. Maximum production capacity of these 2 firms available for transit bus engines without significant added capital is estimated at about 40,000 units annually, which far exceeds the total demand from the transit bus market.

Cummins Engine Company has indicated that the lack of financial incentives has constrained the development of improved products. It is felt that the ADB procurement on the basis of low bid does not properly compensate Cummins or any other company for a superior product. They feel the VTB-903 fuel economy justifies a significant price offset. In addition, the company also expressed concern over the present lack of life-cycle experience in the ADB procurement procedure.

b. Air Conditioning System

The industry capability to develop and produce improved technology for air conditioning subsystems and components has been inadequate in terms of either operating reliability or energy consumption as measured from the operating experiences of ADB buses. The development of existing air conditioning systems is regarded as an evolutionary development that has taken place over the lifetime of the New Look bus, or about 20 years. During that period of time, subsystems suppliers have developed individual components which appear to have achieved satisfactory reliability and durability, but neither of the bus builders has yet been able to put together a successful system arrangement of subsystems.

Production capacity of components does not seem to be a potential problem to the industry capabilities to produce vehicles. Trane Corporation manufactures a durable aluminum bus A/C compressor, and estimates its supply capability at 10,000 units per year based on a two-shift operation. Delco Remy maufactures an automotive compressor used in buses and can easily meet supply needs of 5000-7000 units/year. Neither Trane nor Vapor have any problem conforming to DOT standards.

One of the major concern by the manufacturers is pricing. Since the current ADB specifications do not offer optional choices for different A/C subsystems, it inhibits a price premium to quality components and does not provide the financial incentive for product development. The manufacturers believe that the most important industry need is increased training of operator maintenance and service personnel on all brands of air conditioning equipment and controls. (However, the self-serving nature of this comment must be considered.)

c. Wheelchair Lifts

Because of the immediate need and demand for lifts, it appears that there was not significant development and testing of lifts in an operating environment prior to their deployment for regular service. As a result, generally all lifts currently in service are experiencing problems. Improvements are now being made in lift technology by the manufacturers to correct these deficiencies.

Deliveries of lift-equipped buses began arriving at transit properties in 1978. As of July 1979, General Motors delivered 296 lift-equipped buses and had 699 more an order; Flxible delivered 1003 and had 209 on order. In addition, AM General completed orders for 234 lift-equipped buses and 45 buses had been retrofitted with lifts. Gillig-Neoplan also filled an order for 52 small lift-equipped buses in 1978.

At the present time, there are roughly 1500 transit buses equipped with lifts. General Motors uses its own lift in its RTS-2 bus. Flxible had been using the Environmental Equipment Corporation lift, but recently ordered lifts from Vapor Corporation.

Flyer is installing the "Lift-U" lift in the buses it is producing for Seattle, but Flyer has also used the Vapor Corporation lift. The lift made by Transportation Design and Technology, Inc., was used by AM General and served as a retrofit into some older buses. The Transi-Lift has been selected for use in light rail vehicles for San Diego, but this model has not been used in transit buses.

Because ADBs are purchased using a performance specification, manufacturers can install whichever lift they prefer. However, if New Look buses are purchased, the transit property may request a specific lift. Despite the fact that the two U.S. manufacturers tend to be committed to specific lifts, the lift industry appears to be competitive. All lift manufacturers feel there will be adequate business for them in the future. Those lift manufacturers who are not tied into an agreement with a bus manufacturer are actively involved in the retrofit business or are seeking a contract with a manufacturer. The lift manufacturing process is labor rather than capital-intensive, and manufacturers would be able to meet the demand for additional lifts. Vapor Corporation reports that it could produce up to 30 lifts per day.

d. <u>Other General Issues</u>

In all motor vehicle manufacturing, it is very difficult to separate financial performance from the production base (i.e., capacity), because the configuration of production equipment and labor will determine the financial characteristics of the manufacturing company. This is especially true in transit bus manufacture, again owing to the relatively low unit demand for these heavy duty products. Compared to other industrial operations, such as auto or truck production, the overall financial strength of bus divisions or assemblers appear low. Such marginal finances become evident in the capacity decisions. For example, GM's capacity expansion would depend upon duration of demand long enough to provide a one-year salary "cushion" against the mandatory layoff payments mentioned in Section 2.5.2. Using standard costing estimates, GM would incur a cost of approximately $20-$25 million in layoff expenses were it ot drop a shift (1000 workers times 2000 hours times $15 per hour times 95 percent layoff salary requirement).

In the content of auto or truck manufacture, this cost of $20-$25 million is exceedingly low. But in the context of bus manufature, this represents approximately 10 percent of the cost of entirely new bus facilities, based upon estimates in the MITRE report.* If the ADB bus, priced at $130,000, earns the same pre-tax margin at GM corporate (12 percent on revenues), then this layoff cost represents the profit on up to 1600 buses, or almost a complete year's output for the shift. Hence, if financially strong GM can be so seriously affected by demand changes, then smaller companies experience even greater relative impacts of such changes. This is the underlying financial situation in bus production, and reveals the longer term conservative stategies which must be adopted by all participant companies.

Financial Consideration

Although company-specific data are not available, it is clear that financial strength of the bus companies will depend upon a number of factors:

a. Demand

The level and certainty of demand are the most important factors affecting finances, as they are with capacity. Investment decisions in new capacity or new design cannot be justified until demand levels are assured far enough into the future to assure payback on the investment cost. In general, it can be concluded that smoother and longer demand patterns will make increased bus investment relatively more attrative. Manufaeturers can be more assured of payback, and can wait longer to realize returns.

b. Price and Margin

These variables are largely related to demand patterns, although their behavior can be distinguished. Preliminary discussions with manufacturers suggest that current prices are not a constraint to production of existing design buses. Bus prices have recently risen, especially on ADB models and it is assumed the manufacturers are on the road to achieving reasonable return targets in a long-term perspective. In any case, the pricing of buses relates heavily to the commonality of parts with truck production. If bus designs are mandated in such a manner as to separate the more capital-intensive components away from commonality with trucks, price pressures will have to be upward and strong to justify design changes. Variable margin of a particular product, which is the amount of money available to pay fixed costs, such as property taxes, heat, light, power and other overhead items, is used

*Transbus, "An Overview of Technical, Operational, and Economic Characteristics," Mason, et al, The MITRE Corpo., July, 1979.

in a corporation to reflect the relative power of this particular product with other corporate product portfolios. It can be demonstrated that in the case of GM, variable margins on buses do not appear large enough to warrant rapid or often repeated product changes. In some cases, companies' long-term strategic goals can override short-term margin considerations. An example is the present unbalanced two-shift production setup by Grumman, and GM's recent startup of their second shift.

c. <u>Cost and Availability of Capital</u>

In the long-term context, the supply and price of capital funds will represent important constraints upon changes in the bus industry. In general, capital funds flow most easily to higher margin operation, or to growth industries in which higher returns can be expected in the future. As a result of changing energy conditions primarily in auto and truck markets, capital funds in GM are in relatively short supply and come at extremely high cost. In this context, the bus markets are weaker competitors compared to truck or auto operations. This is one fundamental reason for the long product design life schedules on the bus division -- the return is low enough that long product life-cycles are needed to pay off the capital investment. The situtation would be somewhat different for the smaller producers that are completely dedicated to bus markets. However, the smaller company is less likely to have the financial reserves of GM, and would be less likely to attract capital from outside.

2.6 SCENARIO ANALYSIS - CONVENTIONAL ROAD-BASED TRANSIT

The establishment of a range of fleet requirements for the next 10 years forms the foundation from which all other data and conclusions in this study are derived. Data on fleet requirements dictate capital costs, operating expenses, manufacturing production responses, service and facility sizing. The scenarios chosen to develop these fleet requirements represent a range of hypothetical environments, all of which are feasible, some of which appear extreme. However, the purpose of the scenario approach is to bound the problem more than suggest what may happen.

2.6.1 Scenario Description

Four different scenarios are developed based on different constraints and assumptions. One of the scenarios is considered the most probable based on an independent reasonableness check. The four scenarios are as follows:

Scenario I - This scenario is best described as "business as usual" in terms of availability of Federal funding. It assumes that the level of Federal capital assistance remains the same for the next decade as in 1980.

Scenario II - This scenario is best described as "business as usual" in terms of ridership growth. It assumes that the total ridership continues to grow at an annual rate of 4.3 percent.*

Scenario III - This scenario is based on the Administration's objective of increasing the nation's transit capacity by 50 percent in the next decade through the use of Energy Security Fund. (See DOT News, August 29, 1979.)

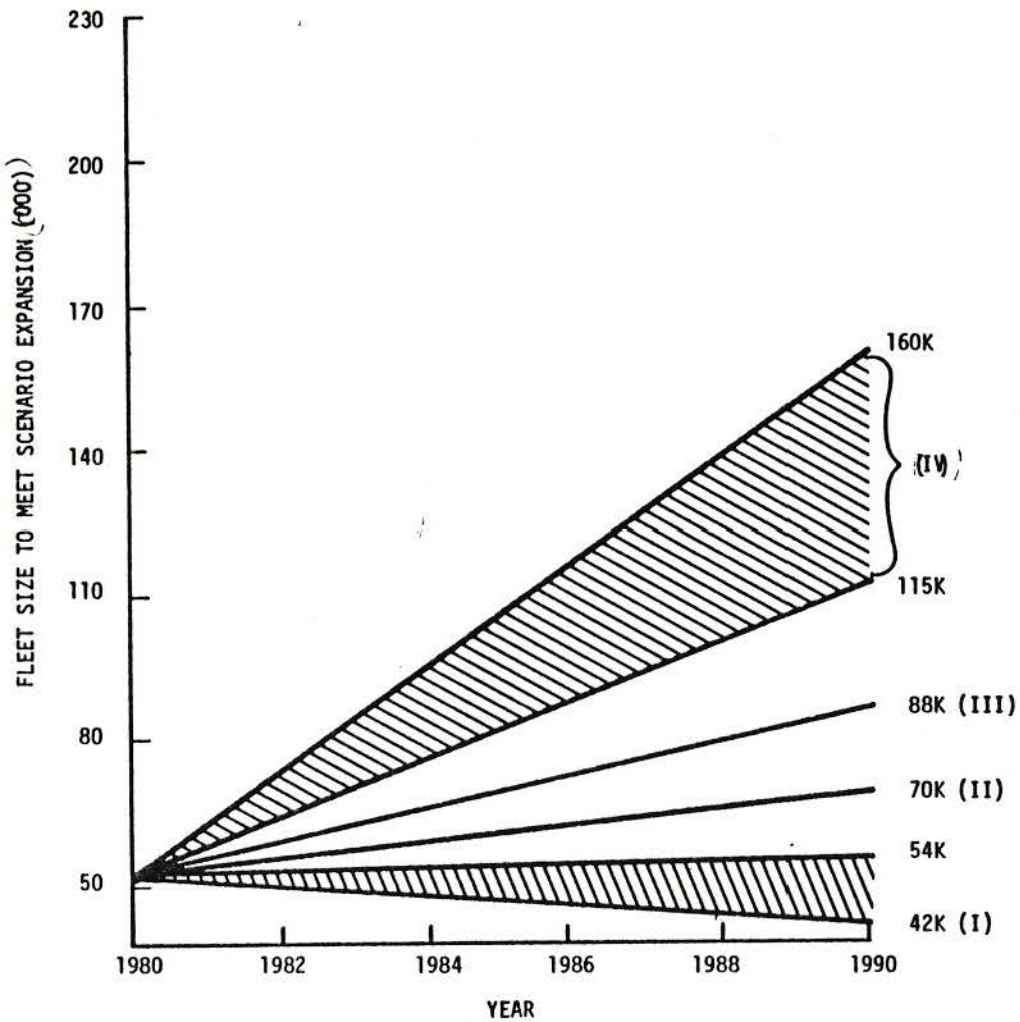
Scenario IV - As in Scenario II, this scenario is also based on increases in ridership. The ridership increase assumes that the present model split captured by the urban road transit will be tripled by 1990.

2.6.2 Fleet Projections and Discussion

For each of the scenarios described above, there is a corresponding range of fleet requirements. Figure 2-13 shows the fleet requirements for the four scenarios. A straight line is assumed between the end points of 52,000 vehicles in 1980 and those estimated in 1990. The fleet estimates are obtained as follows:

Scenario I - Federal bus grant assistance from Sections 3 and 5 has remained between \$550M and \$600M in constant 1980 dollars since 1974. This scenario assumes that the UMTA funding level from Tier IV of Section 5 and Section 3 discretionary funds will remain at \$600M (1980 dollars) per year for road transit vehicles during the next 10 years. This yearly Federal capital assistance translates to 2900 new vehicles per year based on the unit cost of \$120K per new vehicle (80 percent of \$150K) and \$250M for refurbishment of facilities . This relatively low level of capital funding presents a dilemma

*Computed from Transit Fact Book, '77-'78 Edition, American Public Transit Association (APTA), and monthly updates from APTA through August, 1979.



SCENARIO I - Fixed Federal Funding (pre-1980 level)
assumptions: $250M for facility refurbishment.
Low fleet estimate assumes: all $ expended for new vehicles.
High fleet estimate assumes: even mix between new and rebuilts.

SCENARIO II - Business As Usual
Extrapolation of PAX demands

SCENARIO III - Supply Scenario
Based on increasing mass transit capacity by 50% by 1990.

SCENARIO IV - Demand Scenario
Assumes mode share of bus to be 30% of work trip during peak period by 1990.

High fleet estimates assumes: peak period load factors remain at 80 PAX/Pk-hr and utiliz'n of fleet at 0.8.
Low fleet estimate assumes: peak period load factor of 100 PAX/Pk-hr and fleet util'n rates of 0.9.

FIGURE 2-13. U.S. FLEET REQUIREMENTS FOR FOUR SCENARIOS - 1980-1990 for transit properties in need of more vehicles since the total number of vehicles is not sufficient to cover the annual replacements.

If we assume that by 1990 all vehicles in the fleet are to be 12 years or younger, then a little over 40,000 vehicles need to be replaced or refurbished in 10 years or an average of 4000 vehicles per year.* This implies that the total transit fleet will shrink by 1100 vehicles per year based on this scenario if all replacements are new vehicles.

An alternative to buying new vehicles for replacements is to refurbish the old ones. Although refurbishment costs depend a great deal on the condition of the vehicles to be refurbished, an average Federal cost of $50K per vehicle appears reasonable. This cost differential allows a trade-off of 2.5 rebuilt vehicles versus a new vehicle. A reasonable strategy in this scenario would be to order 2000 vehicles per year which is the minimum necessary to keep one manufacturer in the market and use the remaining funding to refurbish 2200 old vehicles. This results in 4200 vehicles per year, which is slightly over the replacement rates as shown in Figure 2-13. It is to be noted that although refurbished vehicles do not have the life of new vehicles, no distinction is made in this report other than their relative cost.

<u>Scenario II</u> - This scenario increases the required fleet by about 35 percent to 70,000 vehicles by 1990. This is obtained by translating the annual passenger ridership increase of 4.3 percent to an equivalent average annual peak period vehicle increase of 3 percent.**

<u>Scenario III</u> - A fleet of 88,000 vehicles by 1990 is projected for this scenario. This represents a 70 percent increase in 10 years or an increase of 5.5 percent per year. The computation is based on the assumption*** that the urban road transit will absorb the entire stated goal of 50 percent increase in transit capacity and that capacity measured in number of vehicles

* The actual replacement rate will have to appreciably be higher in the first few years due to the present age distribution of the fleet.

** This ratio appears reasonable in light of recent APTA estimates (<u>Mass Transit</u>, December 1979, p. 9) that a 26 percent increase in passengers would result in a need for 9,464 additional vehicles (18.2 percent increase in fleet). Also, data on 9 major bus properties in the U.S. show a weighted average of 1.8 for the ratio of percent change in passengers to percent change in peak period buses.

***Further analysis is needed to quantify expansion in capacity over next decade in fixed rail to adjust for this assumption.

or vehicle-miles is comparable. An APTA reported mode share of 75 percent for road transit and 25 percent for fixed rail is used.

Scenario IV - The vehicle fleet requirements for this scenario are expressed in Figure 2.13 as a range of values. The high fleet estimate of 160,000 vehicles assumes expansion proportional to the current fleet utilization of 80 percent and load factors of 80 passengers per peak-hour. The low estimate of 115,000 vehicles is based on an improvement in fleet utilization to 90 percent and an increase in load factor to 100 passengers per peak hour. They are computed based on the following estimates.

	1980	1990
Urbanized Area Population	140 million	163 million
Urbanized Area Workers	65 million	75 million
Number of Work Trips per Year	30 million	35 million
Number of Work Trips by Road Transit During Peak	3.5 billion (11.7%)	10.5 billion (30%)
Number of Vehicles Required	52,000	160,000

It is very interesting to note that, although these fleet requirements appear relatively high, APTA remarks in the December 1979 issue of Mass Transit that if gasoline lines return, many of their constituency feel a 20 percent annual increase in ridership could occur. This translates to a 14 percent increase in annual fleet requirements, well within the range of Scenario IV. In addition, mode share of 30 percent or more of the journey-to-work trip are relatively common in Europe.

Discussion

With the resurgence of mass transit over the past few years, it is clear that the lower level of Scenario I is unsatisfactory. At the other end of the spectrum, a tripling of the current fleet to a level of 160,000 vehicles appears equally unrealistic, since the density of road transit service would clearly require consideration of fixed rail or guideway systems. Based on the criteria of the number of transit vehicles per million population of the entire urbanized area in 1990, it is reasonable to expect that the fleet expansion will lie somewhere between Scenario II and Scenario III. This represents a growth from the present 375 vehicles per million population to a projected 430 vehicles per million population for Scenario II and 540 vehicles per million population for Scenario III.

Figure 2-14 presents the 10-year annual average of vehicle orders required for each scenario and the high and low range for each scenario where applicable. These bar chart values represent the total of new orders to meet fleet expansion and replacement. To maintain a 12-year life, approximately 4000 vehicles need to be replaced each year (ignoring for the moment the real age distribution). For example, in Scenario II, the 4000 vehicles per year needed for replacement are added to fleet expansion requirements of 1800 vehicles per year for a total annual average order for the decade of 5800 vehicles. In Figure 2-14, this total is disaggregated to vehicle types using fleet mix percentages proportional to orders received in recent years, adjusted slightly in Scenario II through IV by the assumption that there will be an increase in the demand for small and large capacity vehicles. The former is justified on the basis of the market capture projections given in the Trends and Status Section. The latter assumption makes sense on the basis of recent emphasis on increased productivity. Specifically, the following annual market guideline is used to arrive at the <u>baseline fleet mix</u> for each scenario.*

- o 500 rebuilt
- o 60-100 trolley buses
- o 500 New Look vehicles (with a slight increase at high order rates)
- o 86 percent of remaining fleet requirement will be Advanced Design Buses (ADB)
- o 11.5 percent of remaining fleet requirement will be small vehicles
- o 2.5 percent of remaining fleet requirement will be large capacity vehicles

It was recognized that the demand for small and large capacity vehicles would most likely increase over the current combined fleet share of about 10 percent. The total share of these vehicle markets was increased to 14 percent for Scenarios II and III, and up to 24 percent in Scenario IV. With changing travel patterns and increased emphasis on productivity, a substantial fleet share for both the small and large capacity vehicle is probable. Table 3-1

*The fleet mix for Scenario I is fixed by the definition of the high and low range for that Federal grant constrained scenario.

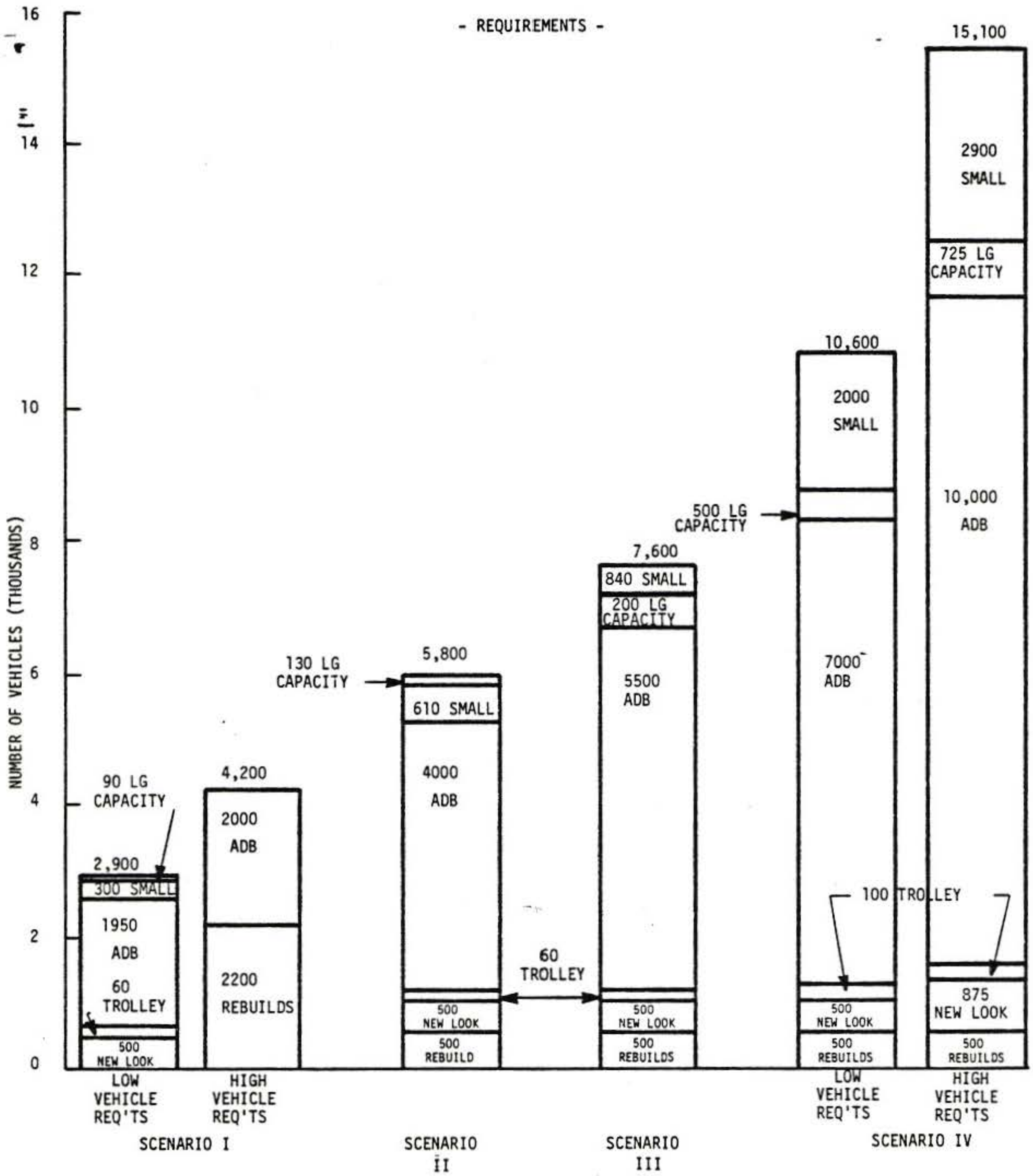


FIGURE 2-14. AVERAGE ANNUAL VEHICLE ORDERS (1980-90)

provides a parametric analysis of some of the impacts that may result from greater market shares for these vehicle types. Given that the most reasonable scenario is between Scenario II and III, Table 2-2 indicates that annual new orders for small and large capacity vehicles could reach in excess of 1700 and 400, respectively.

While Figure 2-14 views all vehicle orders as annual averages, Figure 2-15 specifically examines only ADB orders on a year-by-year basis. The order outlines shown for each scenario in Figure 2-15 are adjusted in the early period of the decade to reflect a certain degree of response time at the state and local level, independent of the manufacturer's backlog. Local planning documents must be updated to include new vehicle procurement plans. These plans must then be approved at the local level. Matching capital funds must also be authorized and committed and capital assistance grants must be processed. Additional time is necessary for the bid processing to be completed before an order for transit vehicles can be placed with the manufacturer. A flow chart tracing a typical road transit vehicle procurement process is given in Appendix B. The slope of the curve is based on the optimistic assumption taht state and local inertia can be overcome to reach 4000 vehicle orders in one year.

In each scenario the yearly orders eventually level off at a value somewhat higher than the annual average of Figure 2-14. This is a result of compensating for the lower than average orders in the early years of the decade. Once local and grant process inertia are overcome, the overall shape of the order outline for the decade could be altered to support other objectives.

2.7 IMPACTS

This section analyzes the funding requirements for the four scenarios depicted in the previous section. Separate considerations are given to the capital equipment and operating costs, as well as to Federal share and state and local share of these costs. Details on the approach and derivation of operating data used in this section are provided in Appendix F.

2.7.1 Capital Cost

Based on the fleet requirements developed for the four scenarios, the total capital cost (in 1980 dollars) for each are estimated and given in

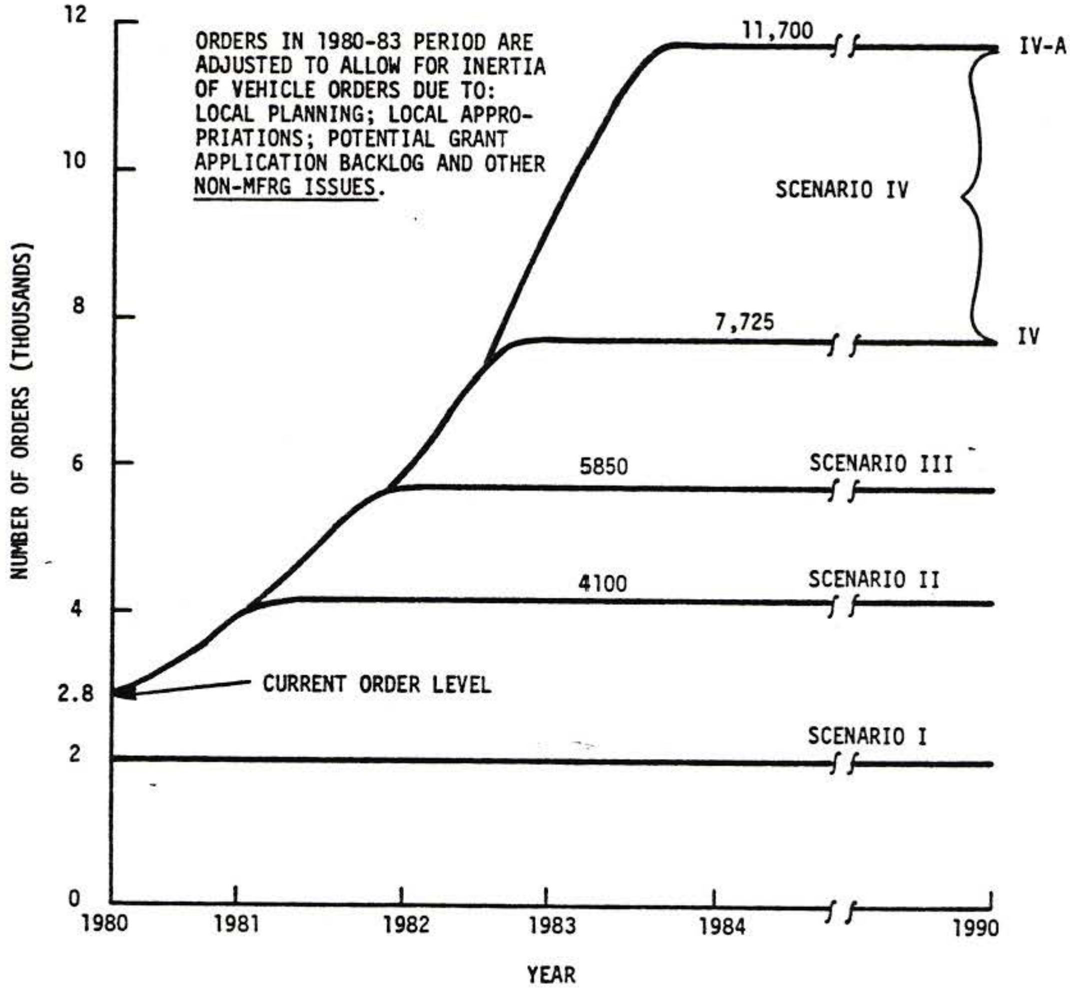


FIGURE 2-15. PROBABLE YEARLY ADB ORDERS - 1980-1990

TABLE 2-2. IMPACT FROM ALTERNATE MARKET SHARES OF SMALL & LARGE CAPACITY VEHICLES

Scenario	Total New Annual Vehicle Orders	Baseline Vehicle Orders (Ref. Fig. 2-14)	Potential Share of Fleet SM & LG Combined	Total Small & Large Capacity Vehicles	Small Capacity Vehicle Share(1)	Large Capacity Vehicle Share	Impact on Total New Std. Vehicle Orders Compared to Baseline(2)	Impact on Absolute Seating New Capacity/Yr Compared to Baseline(3) (Seats/%)	Impact on Funding Requirements(4)
I (LOW)	2,900	300 small 90 large	20%	580	464	116	-190(-7.5%)	-2800(-2.2%)	$ -9.7M
		(for 13.4%) plus	25%	725	580	145	-335(-13.3%)	-4500(-3.6%)	$-15.7M
		2510 std.	30%	879	696	174	-480(-19%)	-6240(-4.9%)	$-21.8M
I (HIGH)			N/A						
II	5,300	610 small 130 large	20%	1060	848	212	-320(-6%)	-3100(-1.3%)	$-10.9M
		(for 14%) plus	25%	1325	1060	265	-585(-11%)	-6300(-2.7%)	$-22M
		4560 std.	30%	1590	1272	318	-850(-16%)	-9480(-4.1%)	$-33.2M
III	7,100	840 small 200 large	20%	1420	1136	284	-380(-5.3%)	-4240(-1.4%)	$-14.8M
		(for 14.6%) plus	25%	1775	1420	355	-735(-10%)	-8500(-2.3%)	$-29.7M
		6000 std.	30%	2130	1704	426	-1090(-15.3%)	-12,760(-42.%)	$-44.7M
IV (LOW)	10,100	2000 small 500 large	20%	2020	1616	404	+480(+4.7%)	+5760(+1.4%)	$+20.4M
		(for 25%) plus	25%	SAME AS BASELINE					
		7600 std.	30%	3030	2424	606	-530(-5.2%)	-6360(-1.5%)	$-22.3M
IV (HIGH)	14,600	2900 small 725 large	20%	2920	2336	584	+705(+4.8%)	+8460(+1.4%)	$+29.6M
		(for 25%) plus	25%	SAME AS BASELINE					
		10.975	30%	4380	3504	876	-755(-5.2%)	-9060(-1.5%)	$-31.7M

(1) A ratio of 4 small buses to every large capacity vehicle is assumed. This represents a slight decrease (from 4.6) in small vehicle orders and an attendant increase in large capacity vehicles compared with the current fleet mix.
(2) Assumes all increases in large and small new vehicle orders come from new standard bus orders.
(3) Assumes 45 seats on standard-size vehicle; 65 on large capacity; 25 on small.
(4) At $130,000 per new standard-size vehicle, $60,000 for small and $200,000 for large capacity vehicles.

Figure 2-16. The cost estimates are based on the following assumptions:

a. Constant level of $250 million yearly is allocated for refurbishment of existing facilities.

b. Average capital cost of $150,000 per vehicle. (The weighted average of large capacity and small vehicles approximately equals the cost of ADB projected to 1980 price of $150,000.)

c. Rebuilt vehicles cost $60,000 each.

d. For each new vehicle that is considered part of expansion, an additional increment of $50,000 per vehicle is included for facility expansion.

Capital requirements for Scenario III are shown as a range: the lower value is indicative only of additional vehicles; the high level denotes the cost of vehicles plus any costs for dedicated busways, new shelters, or stations that are often considered necessary for expanded service. Similarly, capital requirements for Scenario IV are shown as a range due to both variable fleet requirements and the need for additional shelters and busways attendant to such a large increase in road transit fleet.

The capital requirements shown in Figure 2-16 are in no way meant to indicate that constant yearly expenditures are probable or even desirable. The Energy Security Fund will provide varying amounts of revenue over the decade. Also, if past years are any indication, Federal funds available will not be totally committed in any given year frequently resulting in carryovers. Therefore, factoring in such realities, there is a good change that capital dollars required in the later part of the decade (1983-1990) will be incrementally higher than the 1980-1982 period in order to accomplish the scenario goals by 1990. The uncertainties affecting this situation make it too speculative to adjust our macro-analysis of yearly capital requirements at this time.

Figure 2-17 is provided to graphically show two important points. First, assuming current Federal capital grant share remains at 80 percent, state and local matching funds prerequisite to acquiring grant assistance must increase to $230 million (53 percent) under Scenario II conditions, $300-$400 million (100 percent-167 percent) in Scenario III, and in excess of $600 million

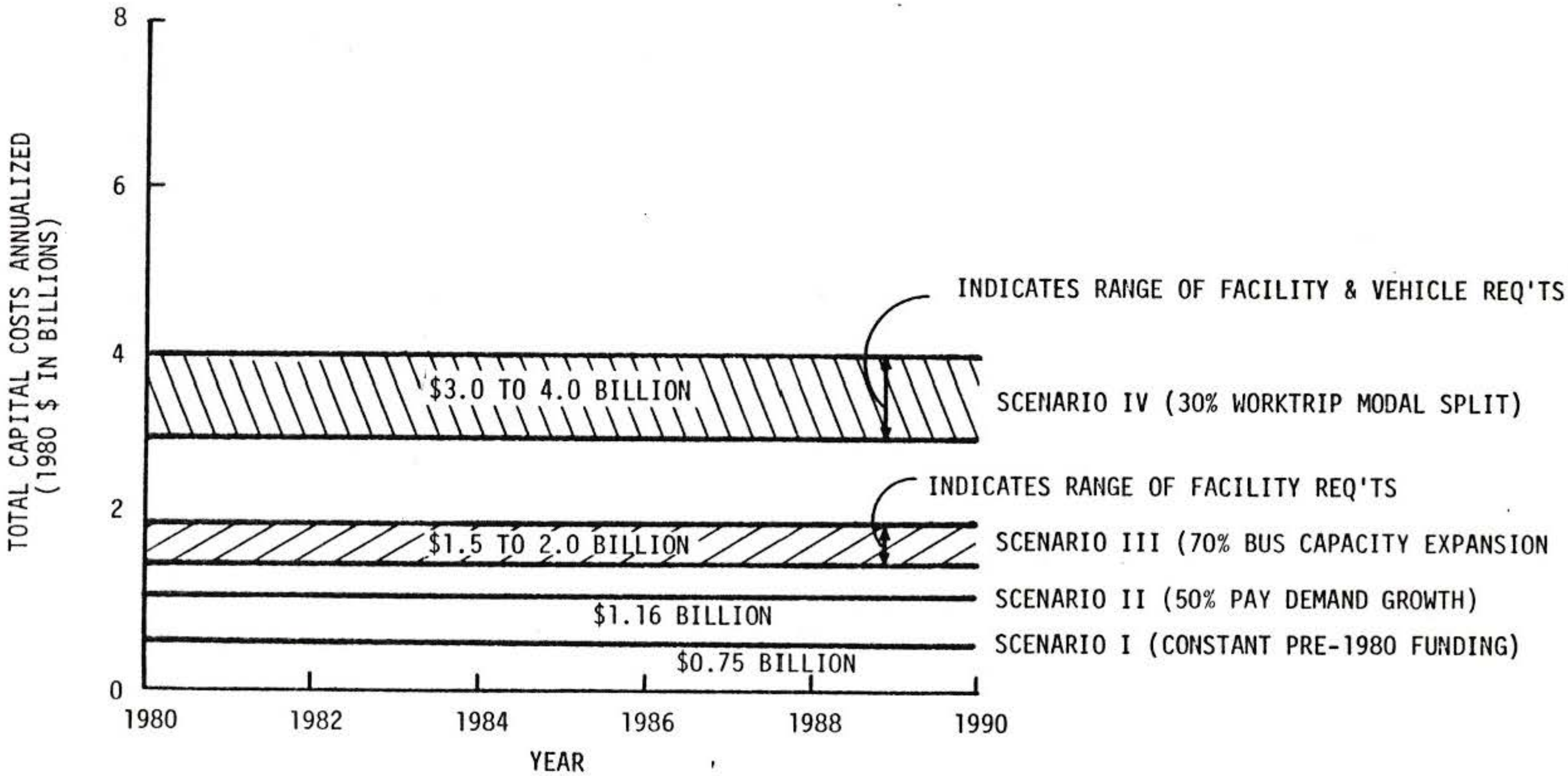


FIGURE 2-16. TOTAL YEARLY CAPITAL COST REQUIREMENTS - 1980-1990

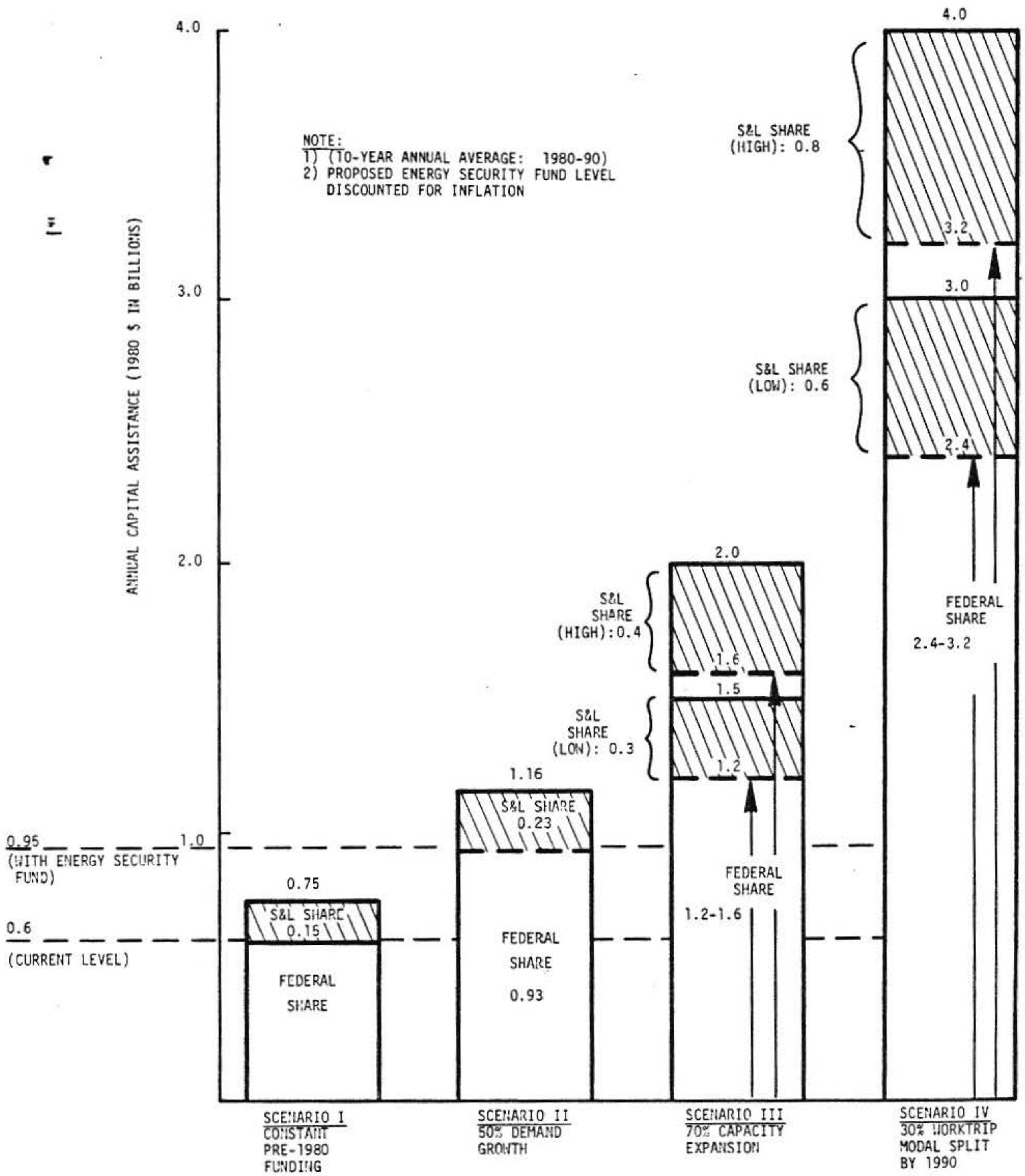


FIGURE 2-17. CAPITAL FUNDS REQUIRED FOR FEDERAL, STATE AND LOCAL COMPARED TO WHAT MAY BE AVAILABLE

(400 percent) under the 30 percent mode split environment of Scenario IV. Without making any judgments on the inadequacy or appropriateness of current capital grant assistance policies, it is important to realize the financial burden that could be placed on the state and local governments in the next decade. Also, as shown later in this study, this burden represents only a small fraction of the larger financial responsibility -- the operating deficit.

The second purpose for this graph is to demonstrate the adequacy and inadequacy of current and augmented (with Energy Security Fund) Federal capital assistance. Scenario II appears to have adequate annual Federal capital funding available, given the existence of an Energy Security Fund; however, the higher estimate of Scenario III and all of Scenario IV would have insufficient Federal capital grant dollars to permit expansion.

2.7.2 Operating and Maintenance Cost

As alluded to previously, the most serious financial assistance issue is the operating cost associated with an expanded fleet. To estimate total requirements for operating expense for the various fleet sizes, a macro-analysis approach was again employed. Operating costs (expenses for operations, maintenance, and management, not including depreciation or amortization) extrapolated from current APTA data to 1980, results in costs of about $2.50 for each vehicle-mile. Similarly, estimates of average annual vehicle-miles per vehicle for 1980 are 35,000. From this information, the following chart can be developed.

SCENARIO	FLEET SIZE (thousands)	TOTAL VEHICLE-MILES BY 1990 (billions)
I (High)	54	1.9
I (Low)	42	1.5
II	70	2.4
III	88	3.1
IV (High)	160	5.6
IV (Low)	115	4.5

At an estimated cost of $2.50 per vehicle-mile, these values translate into requirements for the total operating expenses shown in Figure 2-18. Curves representing requirements for Scenarios III and IV have been adjusted to indi-

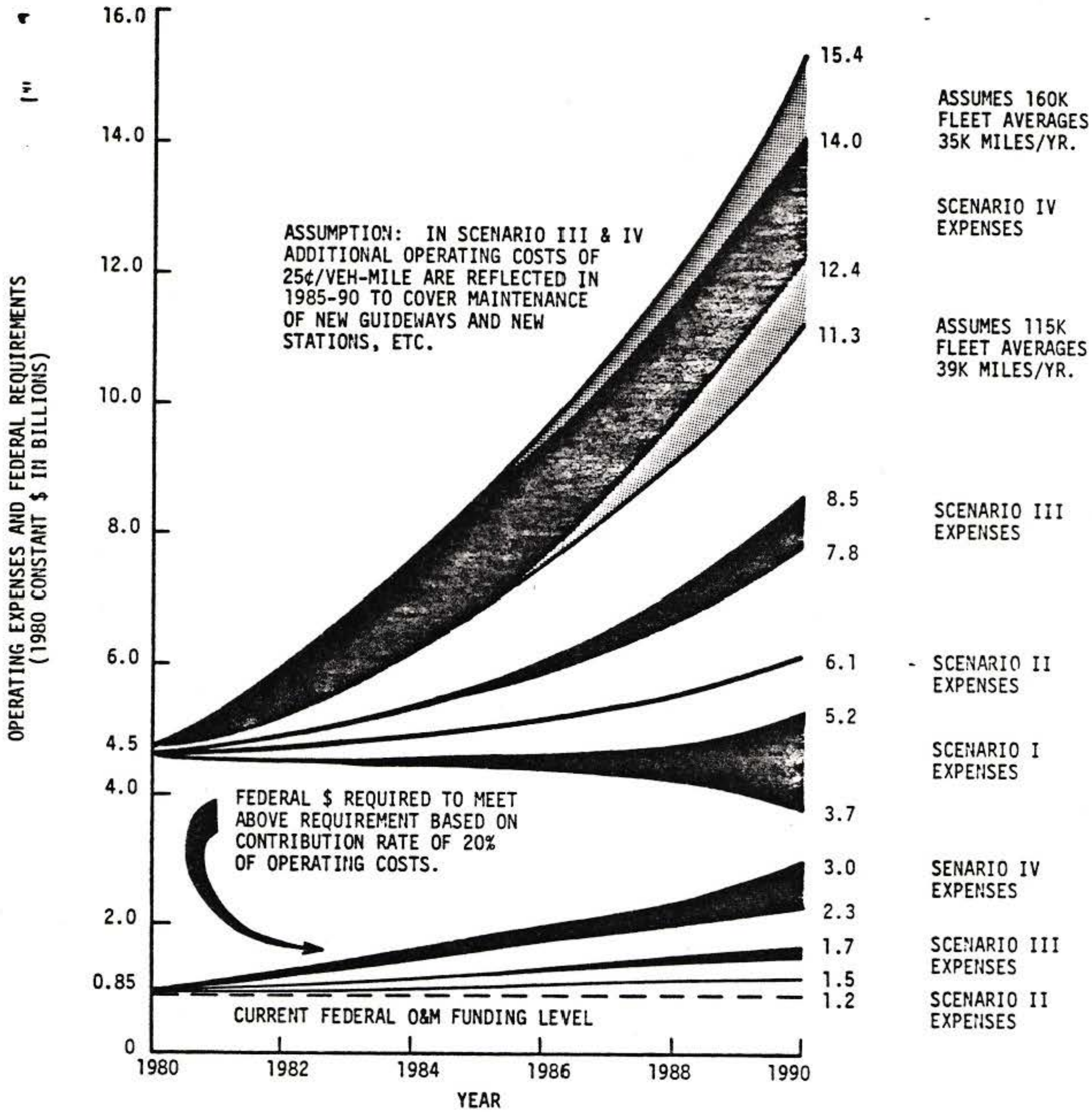


FIGURE 2-18. REQUIREMENTS FOR OPERATING EXPENSES AND FEDERAL ASSISTANCE - 1980-1990

cate a probable increase in operating expenses to cover maintenance of projected new stations, shelters, and guideways that are associated with such a large fleet expansion.

Federal Subsidy

Based on the assumption that the current share of operating costs provided by the Federal Government continues at an average of about 20 percent, it is possible to represent Federal operating assistance required for each scenario as shown in the lower portion of Figure 2-18. Current Section 5 funding appears roughly sufficient for the full range of Scenario I, therefore, it is not shown in the lower portion of Figure 2-18. Clearly, anywhere from 41 percent to 250 percent more Federal assistance money could be needed to meet the requirements of Scenarios II, III, and IV.

State and Local Subsidy

A more severe problem is demonstrated by Figure 2-19. The deficit, currently paid by state and local governments, represents about 40 percent of the total operating expense. Under Scenario II, the burden is 50 percent greater; 94 percent larger for Scenario III as a minimum, and at least three times as large for Scenario IV. The total financial burden, including capital and operating costs, on the state and local communities under each scenario is shown in Figure 2-20.

Realizing capital commitment rates and operating requirements are not attained quickly, the values on this bar chart of Figure 2-20 are adjusted slightly from the respective values from Figures 2-17 and 2-19. In effect, these adjustments result from two factors. First, capital commitment rates are assumed to remain at current levels, approximately $2.2 billion for the 1980-1982 time frame, then escalating for the remaining seven years sufficiently to meet capital requirements of Figure 2-16. This is based on a number of institutional issues which typically create inertia in increasing government expenditures. Second, operating costs for the 1980-1982 time frame are tempered slightly to reflect a more realistic growth to 1.9 billion vehicle-miles for all scenarios by the end of 1982, then escalating to meet total operating requirements shown in Figure 2-19. This modification reflects the low capital commitment rates and an assumption that, as a result of the age distribution of the current fleet, new vehicles purchased during this

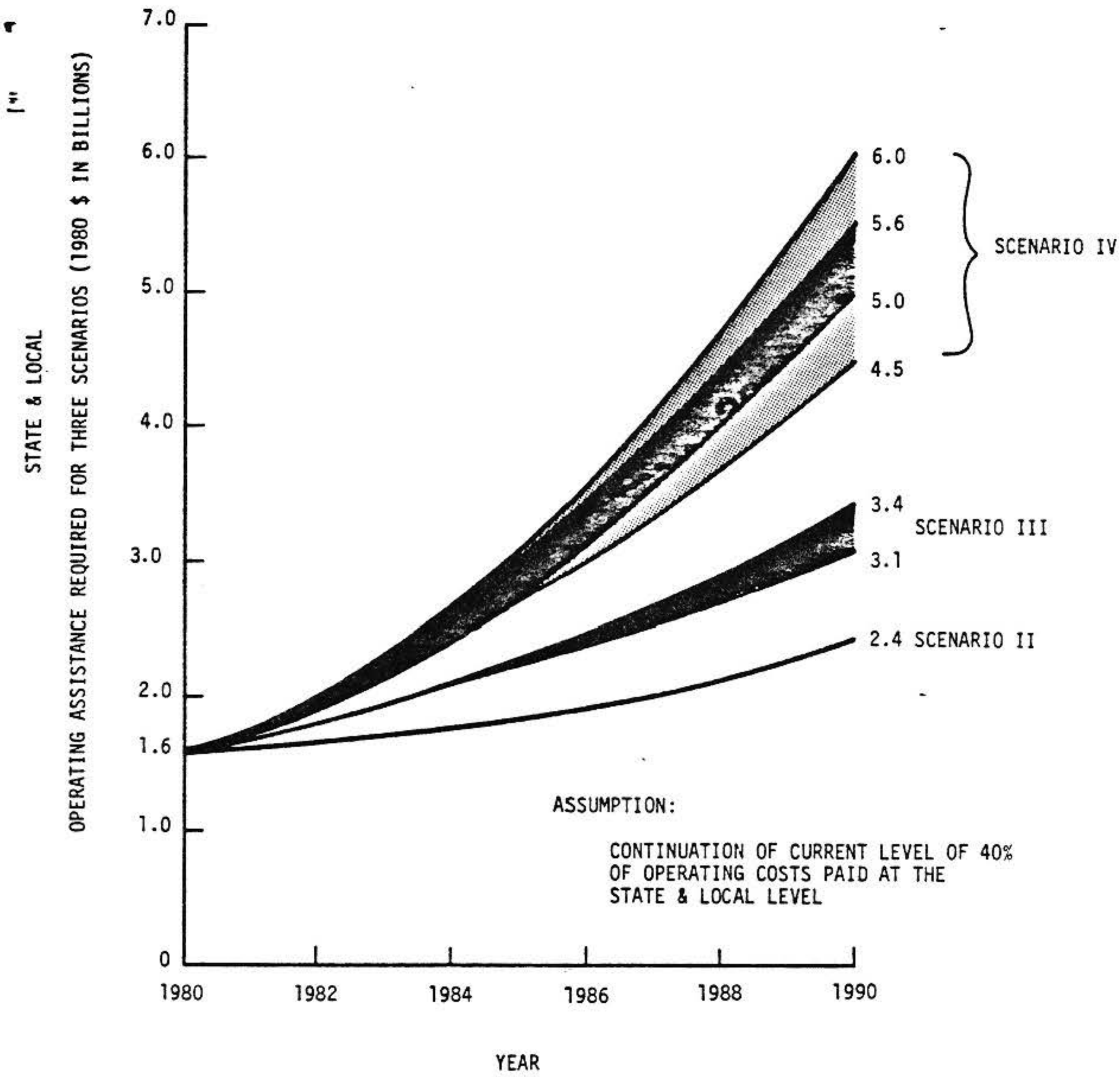


FIGURE 2-19. REQUIREMENTS FOR STATE & LOCAL OPERATING ASSISTANCE (DEFICIT) - 1980-1990

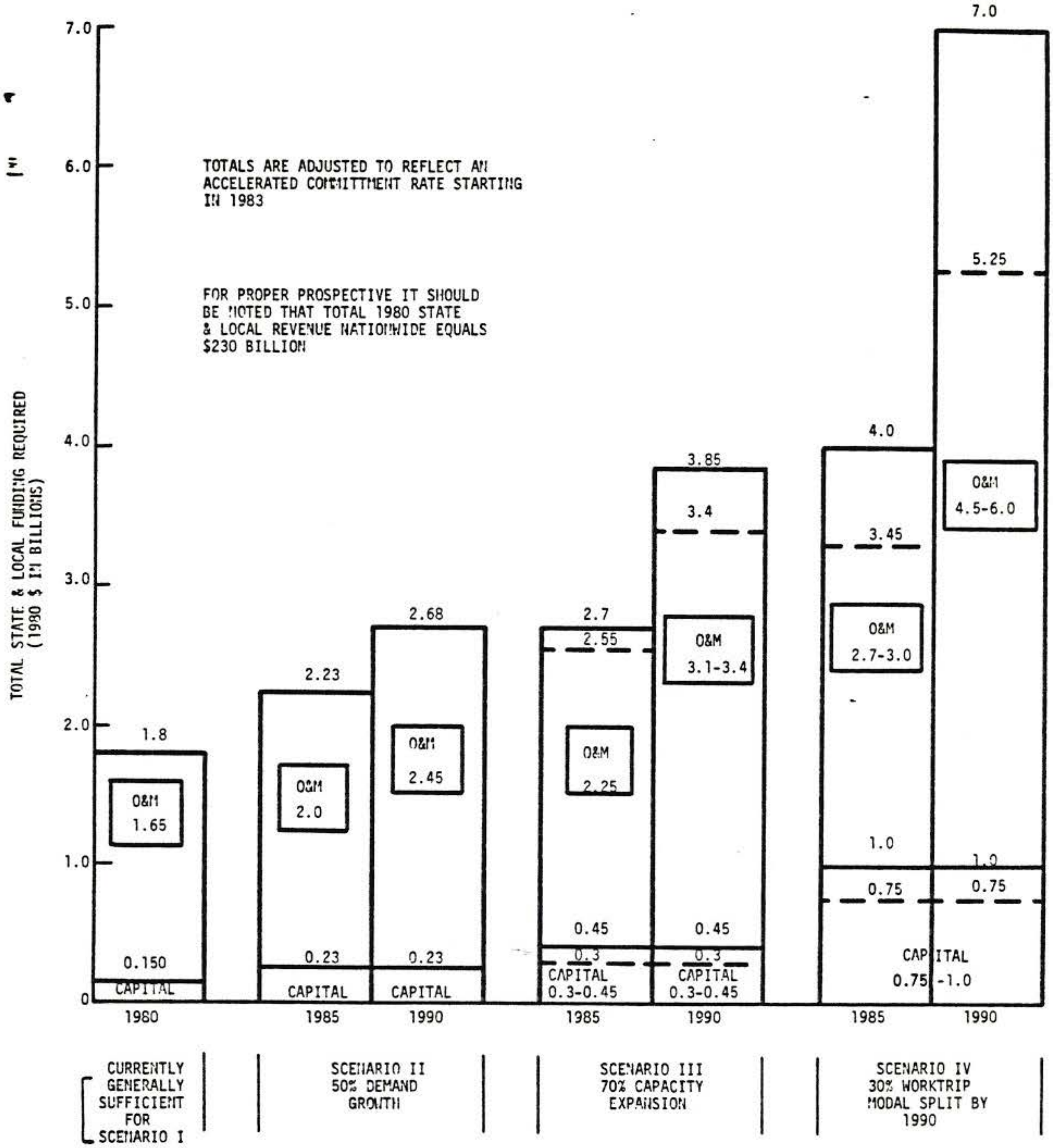


FIGURE 2-20. TOTAL STATE & LOCAL FUNDING REQUIREMENTS FOR TWO DISCRETE TIMES - 1985 AND 1990

period may replace more than one retired vehicle. Therefore, the change in vehicle-miles for each new vehicle delivered is not as high as it would be once the retirement rate is stabilized.

2.7.3 Requirements for Maintenance, Operations and Management

Expansion of bus supply will require an increase in supporting facilities and personnel. In addition, improved productivity and better management tools will be required if tight control is to be maintained over operating costs. This section addresses the facilities/equipment and associated labor required in the areas of maintenance, operations and management.

2.7.3.1 Maintenance - A high proportion of previous capital expenditures for bus transit has been devoted to supporting facilities and this is likely to continue.

a. Facilities and Equipment

Additional buses will require an extension of or additional facilities for service (fueling, inspection, storage) and maintenance (repair and overhaul). In addition, many of the service and maintenance facilities in use today are obsolescent. A survey of maintenance and service facilities conducted in 1975 revealed that approximately half were over 30 years old -- some actually predated the electric streetcar era.

In gross terms, completely new facilities (including outside storage) would cost approximately 25 percent of the cost of the new fleet expansion; with inside storage the costs rise to 40 percent. The cost of refurbishing existing facilities is obviously less than this. An estimate of the capital costs, over a 10-year period, for each of the scenarios, and an estimate of the cost for refurbishing/replacing existing facilities is shown in Table 2.3.

Expanded bus fleets, demands for increased equipment utilization, and shortages of transit personnel will necessitate increased use of diagnostic tools and techniques. Examples are:

- Automatic Diagnostic Equipment - Automatic diagnostic equipment has proved successful for truck operations, and a demonstration is now being conducted of its application to diesel buses at the New York

TABLE 2-3. IMPACTS OF FLEET INCREASES ON MAINTENANCE, OPERATIONS, AND MANAGEMENT

SCENARIO	NUMBER OF BUSES	NEW FACILITY COST (millions)*	REFURBISHED REPLACED FACILITY COST (millions)	TOTAL (billions)	NUMBER OF ADDITIONAL MAINTENANCE STAFF	NUMBER OF ADDITIONAL DRIVERS	ADDITIONAL ADMINISTRATIVE STAFF	TOTAL PERSONNEL REQUIRED
I*	52,000	--	750	0.75	(13,000)	(84,000)	(21,000)	(118,000)
II	70,000	770	750	1.52	6,600	26,000	7,400	40,000
III	88,000	1,460	750	2.21	13,000	52,000	15,000	80,000
IV (LOW)	115,000	2,535	750	3.28	23,000	91,000	26,000	140,000
IV (HIGH)	160,000	4,220	750	4.97	40,000	157,000	43,000	240,000

*Numbers in parentheses indicate current staff.

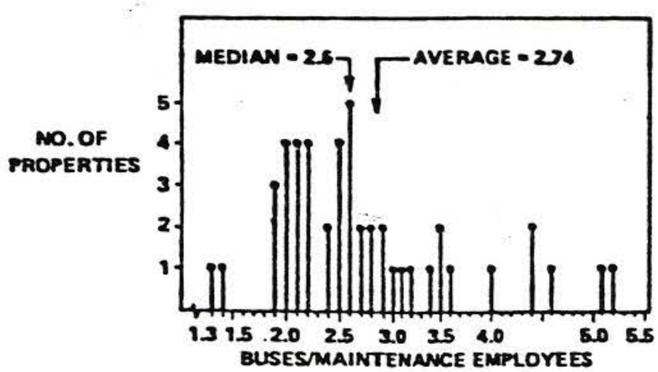
City Transit Authority. Extensive use of this technique will require that consideration be given to installing the appropriate sensors and transducers at the time of bus manufacture.

- Spectrochemical Oil Analysis - Spectrochemical oil analysis, a proven technique for detecting incipient failures in diesel engines, is already in limited use in the transit industry. One transit system increased the oil change period from 6000 to 12,000 miles following the introduction of spectrochemical oil analysis.

- Dynamometers - Increased emphasis on fuel efficiency implies the ability to adjust diesel engines under loaded conditions. Dynamometers are in use in some transit systems to allow static load tests to be performed, and are likely to move into more extensive use as bus fleets expand.

b. Personnel

Recruitment of additional personnel will be necessary as the fleet expands. Figure 2-21 shows the spread of buses/maintenance employee for a sample of 47 transit properties. Table 2-3 shows the number of additional maintenance employees required for each of the scenarios.



Source: Thurlow, V., et al., "Bus Maintenance Facilities: A Transit Management Handbook," MITRE Technical Report, MTR-7080, 1975.

FIGURE 2-21. MAINTENANCE EMPLOYEE REQUIREMENTS

2.7.3.2 Operations - Several techniques and systems currently being demonstrated can be applied to improve the efficiency of bus transit.

a. Facilities and Equipment

- Vehicle Control and Assignment - Only limited in-service control of vehicles to ensure schedule adherence and to minimize over- or under-loading is currently practiced. A successful demonstration of automatic vehicle location; automatic passenger counters; and real-time control strategies will lead to an increased demand for this type of equipment. Analyses have indicated that cost savings resulting from these techniques are significant.*

- Passenger Information - Expanded ridership will lead to an increased demand for information on routes, schedules, and fares. Computer-assisted telephone information systems are now being installed in Washington and Los Angeles. Developments in computer technology now make this approach cost-effective for smaller systems also -- particularly where routes and schedules are changing frequently. Real-time displays of bus information are currently being tested in Cincinnati and elsewhere.**

- Passenger Shelters - Studies have consistently shown the need for adequate shelter at bus stops if additional ridership is to be developed. Attractive, vandal-resistant shelters capable of meeting the needs of the passenger and also blending in with the environment are currently available. Since even a medium-size system will have over 1000 bus stops, passenger shelters will be a major capital item in future procurements.

- Terminals - In addition to individual passenger shelters, terminal facilities will have to be provided or upgraded to mode or vehicle change points. Park-and-ride and Kiss-and-ride facilities must be integrated with bus loading bays to provide for safe, sheltered, transfer from one vehicle to another. Passenger information displays must be integrated with the terminal facilities. Security

*U.S. Department of Transportation, Transportation Systems Center (1977) "Benefit-Cost Analysis of Automatic Vehicle Monitoring."

**"The Real World of Public Transit," EP-78172, General Motors Corp., 1979.

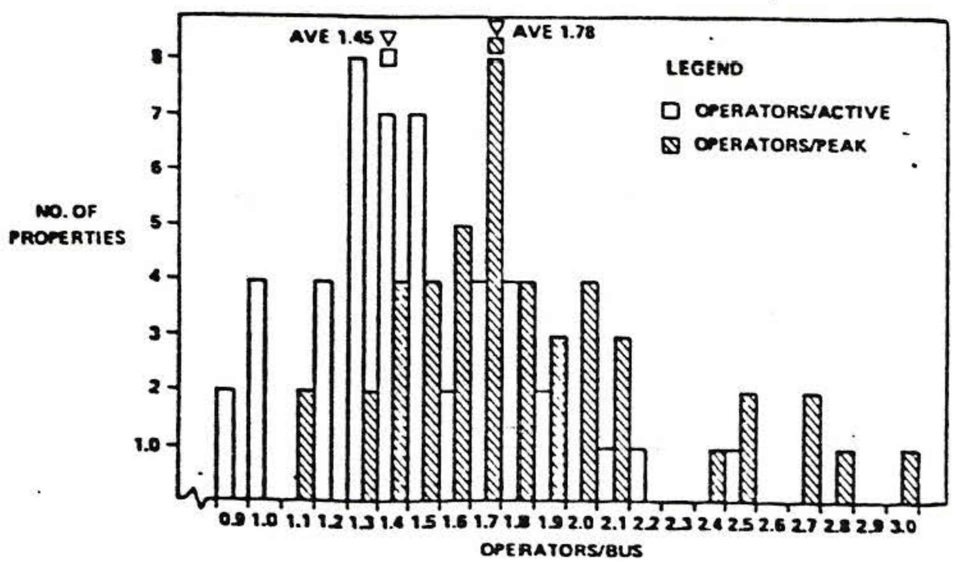
will be enhanced by locating these terminals at high activity centers--such as downtown and suburban shopping malls. Provision of integrated mass transit facilities should be considered a necessary prerequisite before construction permits are issued for all new major commercial (shop and office) facilities.

b. Vehicle Priority Systems

Expanded services will require expanded application of preferential treatment techniques for high occupancy vehicles. Table 2-4 lists a number of such techniques that have proved to have a favorable impact on both operations and ridership. Many of these are low-capital cost items. Others can be implemented with the use of highway transit funds.

c. Personnel

Figure 2-22 shows the number of bus operators/bus at a sample of 47 transit systems. The ratios are shown in terms of operators/peak fleet and operators/total active fleet.



(Source: Thurlow, V., et al., "Bus Maintenance Facilities: A Transit Management Handbook," MITRE Corp., MTR-7080, 1975.)

FIGURE 2-22. VEHICLE OPERATOR REQUIREMENTS

The projected numbers of additional operator personnel required for each of the scenarios is shown in Table 2-3.

TABLE 2-4. PRIORITY FOR HIGH OCCUPANCY VEHICLES

<u>Freeway</u>

1. Exclusive and separated lanes
2. Exclusive but not separated lanes
3. Single lane in contraflow direction
4. Separate access ramps or other "queue jumping" techniques

<u>Major Arterial</u>

1. Single lane in contraflow direction
2. Restricted lane (curbside)
3. Intersection signal preemption

<u>CBD Street</u>

1. Restricted lane (curbside)
2. Contraflow lane (curbside) on one-way street
3. Bus-only streets
4. Exemption from left-turn restrictions
5. Intersection signal preemption

<u>Miscellaneous</u>

1. Exclusive lane at toll plazas
2. Reduced toll charges
3. Preferential parking locations and/or rates

2.7.3.3 Management - Labor cost and productivity are two of the major problems that currently face management and will continue to be a major challenge if the previous projection of operating costs are to be adhered to. Additional administrative personnel will also be required to support expanded bus services.

a. Labor Costs

Transit operating costs increased by $2.4 billion during the period 1967-1976. Of this increase, approximately one-half was due to inflation. However, 28 percent ($680 million) was due to wage and fringe benefits over and above inflation. The recent tendency to include a cost-of-living escalator clause in contracts will only exacerbate this trend.

One method of reducing operating costs is the introduction of part-time labor to handle the operating peak, particularly drivers. Use of part-time labor has tended to be concentrated in the small systems. Recently, however, five major transit systems* have been successful in introducing part-time labor. There are limitations in the use of part-time labor. For example, WMATA is limited to 10 percent of all operators and Seattle is limited to a maximum of 600.

b. Productivity

Coupled with the increase in labor cost, there does not appear to be any significant emphasis to improve labor productivity. Depending on the measures used, productivity during the last few years can be shown to have sustained a marginal increase to a substantial decline. Table 2-5 gives the representative measures for selected U.S. and European Bus Operations (the data are obtained from the VITP Handbook of Urban Transport 1975 and 1979). On the other hand, the same report shows that the number of employees per million passengers, which is another measure of road transit productivity, has shown a steady increase in the U.S. since 1960 (Table 2-6). In contrast, European systems typically have a ratio of 18 employees/million revenue passengers in 1979.

Some of the techniques described previously will result in an improvement in productivity. In addition, improved management information systems (to

*Baltimore, Seattle, Miami, St. Paul and Washington.

TABLE 2-5. REPRESENTATIVE PRODUCTIVITY MEASURES FOR SELECTED U.S. AND EUROPEAN BUS OPERATIONS

	EMPLOYEES PER VEHICLE		VEH-KILOMETER PER EMPLOYEE		KILOMETERS PER VEHICLE	
	1974	1978	1974	1978	1974	1978
UNITED STATES (Average of 10 systems)*	2.14	2.06	23,260 (14,454 mi)	24,407 (15,167 mi)	49,810 (30,952 mi)	50,377 (31,304 mi)
EUROPEAN (Average of 13 systems)*	3.98	3.32	13,700	16,248	49,000 (30,449 mi)	53,904 (33,497 mi)

SOURCE: UITP Handbook, 1975 and 1979.
*U.S. sample includes Baltimore, Cincinnati, Dallas, Detroit, Harrisburg, Miami, Milwaukee, Minneapolis, Omaha, and San Diego.
European sample includes Aarhus, Germany; Brescia, Italy; Havre, France; Heerlen, Netherlands; Liege, Belgium; Lille, France; Lubeck, Germany; Monchengladbach, Germany; Nancy, France; Oberhausen, Germany; and Utrecht, Netherlands.

provide better cost control) and automated scheduling such as RUCUS will also be of benefit. Experience has shown savings of up to three percent in costs, and reductions of up to five percent in the number of operators required by using RUCUS. As transit services expand, RUCUS will become of even more importance to ensure that their services are being provided in the most cost-effective manner, and further expansion of the use of RUCUS should be encouraged.

TABLE 2-6. NUMBER OF EMPLOYEES PER MILLION PASSENGERS FOR ALL U.S. TRANSIT PROPERTIES

YEAR	MEDIAN VALUE
1960	19.8
1965	21.4
1970	23.7
1974	27.9
1978	28.4

c. Personnel

On average, about 18 percent of all transit industry personnel are used in an administrative role. Table 2-3 shows the additional administrative personnel required for each of the scenarios, together with the total (maintenance, operations, and administration) for each.

One point must be made regarding the additional administrative staff. New operators can be introduced and trained in a relatively short period of time, while the skills required of maintenance personnel are comparable to those required in related industries, such as trucking. On the other hand, many of the administrative staff will require specialized skills that require specialized experienced. Examples are service planners and schedulers. A shortage of these types of staff can have an inhibiting effect on service expansions.

3. PARATRANSIT SERVICE

3.1 TRENDS AND STATUS

In contrast to standard transit services, paratransit is much more diffuse and nonhomogeneous. A wide range of services come within its definition. Services often overlap and providers, funding sources, and reporting requirements vary widely. It is difficult to reach definite conclusions since there is little aggregated data available.

Studies conducted on the transportation needs and usage in urban areas have shown that a large percentage of trips have no effective access to conventional public transportation within one-quarter mile or origin. Specifically:

For work trips in all incorporated places:
- 63 percent do not have access to transit
- 27 percent have access but do not use transit
- 10 percent have access and do use transit

For local trips of all types:
- 80 percent do not have access to transit
- 15 percent have access but do not use transit
- 5 percent have effective access and do use transit

(Source: DOT/FHWA, Nationwide Personal Transportation Survey, Report No. 8, 1973.)

Paratransit service in the form of demand-responsive transit, conventional and shared-ride taxi, and other special services such as carpooling and vanpooling, represents a viable method of providing transportation for those segments for which conventional transit is unsuitable. In addition, it appears to offer the best door-to-door service in the most economical way for mobility handicapped and elderly patrons, as well as the multitude of special services associated with human service programs.

Except for conventional taxicab and jitney services which predate conventional buses, other paratransit services are relatively recent and, in many cases, are still in the evaluation stage of development. There is not sufficient current data available that can be aggregated into a meaningful presentation as it was for the conventional transit. Similarly, it would be speculative to project the future based on the relative short history of paratransit operation. Hence, the discussion on paratransit must, by necessity, be more qualitative than quantitave. It is based primarily on a composite analysis of the many paratransit assessment studies sponsored by the U.S. DOT.

3.1.1 Service Characteristics

Paratransit services cover a broad spectrum of transit services ranging from rent-a-car operations, conventional taxi, carpooling, shared-ride taxi, demand-responsive transit, special services for elderly and handicapped, van-pooling, and subscription service. It complements standard transit services and is intended to act cooperatively to respond to the diverse travel patterns in the urban area. The rapid growth in the 1970s is a reflection of recognizing the need for an integrated mixture of flexibility-routed and conventional transit modes to provide an effective region-wide public transportation system.

For the purposes of this report, paratransit services will be grouped into the following major operations:

- Demand-responsive Operations
- Ridesharing
- Taxi

Demand-responsive Operations

In a broad sense, services provided by demand-responsive transit (DRT) can be categorized into those for the general public and those for special interest groups. A recent study[1] (see Table 3-1) identified in excess of 300 demand-responsive systems in operation providing services to the general public. Current estimates of such services are about one-third higher. The most common DRT service, which accounts for over 80 percent of those catalogued, involves doorstep, many-to-many service. The next most common is many-to-one service, typically a feeder system to a rail or bus stop. Fleet size ranges from a single vehicle to 18 vehicles with a median of 4.6 vehicles. The median weekday ridership is slightly over 200 persons and typically in the larger operations peak-period work trips represent 30 to 40 percent of the ridership. Productivities, measured in passengers per vehicle-hour, range from 2.2 to 10.7, with a median value of 5.8.[1] Data related to paratransit services for the special interest groups are even more scattered. Target

TABLE 3-1. INVENTORY OF U.S. PARATRANSIT SYSTEMS
1978

	General Market	Target Market	Unclassified	Total
Dial-A-Bus	74 (12)**	135 (4)**		209
Shared-Ride Taxi	42 (3)**	27 (3)**		69
Integrated	3	--		3
Mixed*	1	5 (1)**		6
Unclassified	2	11	8	21
TOTAL	122	178	8	308

* Systems which offer both DAB and SRT service.
** The numbers in parentheses indicate discontinued systems which are not included in the totals.

(Source: SYSTAN)

markets such as the elderly and the mobility impaired represent the major concerns of the DOT. This, however, represents only a small percent of the special interest paratransit services. The majority of services, estimated to number as high as 10,000, are provided as an ancillary element of social service programs. The U.S. Department of Health & Welfare is the prime funder for the latter with ridership restricted to particular agency clientele. Generally, the fleets are small, on the order of one to three vehicles.

In contrast to other forms of public transportation, paratransit services in a given area are provided by a multiciplicity of suppliers rather than a single agency. In addition, a wide range of vehicles, including passenger automobiles, converted vans, school buses, and other small buses are used. The large number of vehicle alternatives complicates the vehicle selection process. Also, many systems have been plagued with problems of reliability and vehicle durability.[2] In addition, the lack of corporate stability within the vehicle industry creates a risk committing to a manufacturer who may not remain in business. Although the various types of vehicles available have been compiled,[3,1] there is no consensus concerning the performance of the different vehicles.

<u>Ridesharing, Carpooling and Vanpooling</u>

The oil embargo in 1973 provided much of this nation's impetus to focus on the ridesharing form of transportation. In addition to its demonstrated benefit in reducing energy consumption and pollution, ridesharing also offers indirect benefits in:

- Reducing the need to expand fixed-route transit service into low density areas;
- Reducing congestion on the highways;
- Reducing commuting costs significantly; and
- Reducing employers' subsidized parking expenses.

Recent estimates of ridesharing indicate that 15 million* Americans are carpooling to work which represents 21 percent* of the commuter market. In the larger population areas where organized efforts have been undertaken to

*National Ridesharing Demonstration Program Evaluation Plan (1980).

promote ridersharing, an average of 2.8 of the commuter market had formed or expanded ridersharing arrangements over the three-year period from 1974 to 1977. This broad base shift includes computer matching programs, as well as employer-based and mass media marketing at these selected sites.[4] Sample data from carpooling activities monitored by the Government provides the following composite characteristics:

- Average one-way trip lengths of 12.2 miles;
- Average vehicle occupancy of 2.85 persons;
- Average daily reduction in vehicle miles of 10.8 (44 percent) per carpooler;
- Annual average travel reduction of 0.3 percent of areawide total work trip vehicle miles traveled.

Vanpooling differs from carpooling in that it requires more formal arrangements, typically an assigned driver as well as a backup, compensation procedures, and other administrative support. In addition, the numbers and complexity of interaction of riders increases in vanpooling arrangements. Areas which have already made impressive progress in vanpooling include Los Angeles, Knoxville, Minneapolis, Houston, Rhode Island, and Pennsylvania. Representative summary data on vanpooling operations are provided in Table 3-2. A great deal of progress also has been made in breaking down institutional barriers to vanpooling in areas such as public utility regulation, insurance, labor rules, and constraints on usage of publicly-owned vehicles.

A slight variation of carpooling and vanpooling arrangements is the subscription bus service. Two successful private subscription bus services, one operating in Reston, VA, and the other operating in a number of communities in Southern California, were initiated by commuter groups. The key to the successful deployment of these services appears to be the long trip lengths (20-70 miles).[5]

Conventional Taxicab Operations

Exclusive-ride taxi operations represent a major passenger transportation service in the urban and rural areas. Nationwide, taxi services carry more than one-third as many passengers and receive upwards of twice the combined revenue as other conventional transit modes. Table 3-3 provides comparative information on taxicab industry and transit operating data.

TABLE 3-2. SUMMARY OF VANPOOL PROGRAM DATA

Firm	Number of Vans 1975	Number of Vans 1977	Number of Riders 1975	Number of Riders 1977	Employees Eligible 1975	Employees Eligible 1977
Aerospace Corp. El Segunda, CA	11	19	110	197	6,000	3,000
American Can Co. Greenwich, CT	1	1	11	18	1,800	2,000
CENEX St. Paul, MN	15	20	165	336	700	800
Continental Oil Co. Houston, TX	10	28	103	336	1,400	1,400
Erving Paper Mill Erving, MA	6	6	130	125	300	340
General Mills Minneapolis, MN	15	20	165	225	1,800	1,600
Hoffman-La Roche Nutley, NJ	16	29	120	290	6,000	7,000
Ralph M. Parsons Pasadena, CA	31	33	310	300	4,000	5,000
Scott Paper Co. Philadelphia, PA	2	1	19	9	1,500	1,500
Sperry Rand Phoenix, AZ	10	11	120	132	3,100	3,600
TVA Knoxville, TN	22	130 (163)**	264	1,430 (1,750)**	3,200	3,000 (20,000)**
Texas Instruments Dallas, TX	10	14	120	160	15,600	20,000
3M Company St. Paul, MN	75	92	780	1,030	10,000	10,000
Winnebago Co. Forest City, IO	15	31	250	700	2,700	3,000

*Above 10 passengers, no extra charge
**At multiple sites

PK-Priority Parking, PU-Personal Use (usually at a small fee), DF-Driver Fee

(Source: "Benefit-Cost Analysis of Integrated Paratransit Systems," Report No. UMTA-MA-06-0054-79-5, Vol. I, September 1979.)

TABLE 3-3. COMPARISON OF TAXI AND TRANSIT INDUSTRIES (1975)

	Taxicab Industry	Transit Industry (Rail and Bus)
Vehicles (thousands)	193	62.3
Annual Revenue Passengers (millions)	3,104	5,626
Annual Passenger Revenue (million $)	3,358	1,861
Annual Vehicle-Miles (Millions)	7,739	1,990
Employees (thousands)	365	160

(Source: CDC/Wells Research Co. for U.S. DOT, "Taxicab Operating Characteristics," March 1977.)

More recent statements by representatives of the International Taxicab Association have estimated that the industry consists of more than 5000 companies operating a nationwide fleet of 298,000 vehicles, employing 634,000 workers, serving 3.4 billion passengers annually.[6]

Taxi companies utilize a variety of vehicle types in the provision of their service. The distribution of types of vehicles is shown in Table 3-4. The standard six-passenger taxi vehicle represents the substantial majority of the nationwide fleet.

TABLE 3-4. DISTRIBUTION OF TYPES OF VEHICLES, 1974 AND 1976

Type of Vehicle	Percent of Total	
	1974	1976
Taxicabs	85.4	85.6
Limousines	1.6	2.0
Buses (except School Buses)	2.0	1.1
School Buses	1.1	0.5
Special Vehicles for Handicapped	0.2	0.5
Supervisory Vehicles	1.5	1.1
Tow Trucks	0.5	0.7
Other Service Vehicles	0.8	0.3
Ambulances	0.3	0.2
Rent-A-Car Vehicles	4.8	6.6
All Other	1.8	1.5
Totals	100.0	100.0

(Source: CDC/Wells Research Co., "Taxicab Operating Characteristics," March 1977.)

Work-related and family business trips (shopping, medical, etc.) account for 83 percent of all taxi trips. Table 3-5 shows the distribution of taxicab trips by trip purpose. The demand for service seems well balanced as the family business trips occur during off-peak periods and the work trips occur at peak periods.

TABLE 3-5. PURPOSE DISTRIBUTION OF TAXICAB TRIPS IN SMSAs (1970)

Trip Purpose	All Modes	Taxicabs
Earning a Living		
To Work	26.9	32.0
Related Business	4.0	5.7
Total	30.9	37.7
Family Business		
Medical and Dental	1.8	16.3
Shopping	15.9	16.3
Other	12.6	12.3
Total	30.3	44.9
Education, Civic and Religious	14.4	5.4
Social and Recreational		
Vacation	0.3	-
Visit Friends and Relatives	9.2	5.9
Pleasure Rides	1.4	-
Other	12.5	6.1
Total	23.4	12.0
Other	1.0	-
TOTAL ALL PURPOSES	100.0	100.0

(Source: U.S. DOT, "The Role of Taxicabs in Urban Transportation," Webster, *et al.*, December 1974.)

The average number of passengers per vehicle in the nationwide taxi fleet has remained relatively constant at about 11,000 annually since at least 1973. Average vehicle miles per trip also remain fairly constant at between 5 and 6 miles. Available data on vehicle utilization indicate a slight drop per vehicle from 43,500 miles/year in 1973 to 40,100 miles/year in 1975.

The estimated national average of operating costs of taxicab operations is 43.5 cents per mile. As shown in Table 3-6, driver wages and benefits represented close to 50 percent of this cost in 1978. Current cost information may differ somewhat due to changes in wage and fringe packages, higher insurance rates, and increases in fuel costs.

Direct Federal subsidy from UMTA to private taxi companies is not possible for shared-ride services. However, taxi fares have been subsidized indirectly through service contracts with public agencies receiving Federal funds. For the most part, taxi operations have remained independent of Federal subsidy entanglements. However, it has been argued that the established flow of funding, combined with the tendency of public paratransit service to directly compete with conventional taxi service for similar markets, has often been detrimental to taxicab companies.[7]

There are a number of complex institutional issues that surround the interaction of Federally-subsidized paratransit projects and existing conventional taxi services. These issues include:

- Do Federal (or state) labor protection provisions apply to taxi employees adversely affected by UMTA financial assistance? What are the conditions and extent of coverages?
- What procedural safeguards apply to taxi operations when threatened by deployments of competitive publicly-subsidized paratransit?
- How does the trend toward more taxi drivers operating under an independent contractor status affect contracted services? Similarly, how are labor protections affected?
- What are the implications of Section 504 accessibility requirements on taxi fleets participating by contract in subsidized paratransit operations?
- What are the potential labor implications (and resulting economic

TABLE 3-6. ESTIMATED OPERATING COSTS OF TAXICAB OPERATIONS, FIRST QUARTER 1978

	National Averages, Cents Per Mile	Percent of Total
Driver	22	50.5
Tires	0.5	1.2
Gasoline	05	11.5*
Labor	03	6.9
Parts	02	4.6
Insurance	03	6.9
Depreciation	02	4.6
Dispatching	06	13.8
TOTAL OPERATING COST	43.5	100.0

*NOTE: Recent statement (Taxicab Management, 2/80, p. 8) of ITA President has increased current share of gasoline costs to 14.3%.

(Source: "Taxis, The Public and Paratransit: A Coordination Primer," Prepared for ITA, August 1978. Reprinted by U.S. DOT, Technoloby Sharing Division.)

impacts) of the interaction of unionized fixed-route fleets with non-unionized taxi operations.

These and other related issues must be considered and/or resolved before conventional taxi operations become more closely aligned with public mass transit.

3.1.2 Ridership Characteristics

Unlike conventional bus and rail transit, there is no single source giving aggregated data on annual passenger trips for the paratransit service. Given in Table 3-7 is our best estimate of the annual passenger trips to the various paratransit services described in this report. These estimates were derived based on published information on the number of operational systems and the best data on the average number of vehicles per system and average number of annual passenger trips per vehicle. In most cases, a range is indicated for comparison.

3.1.3 Fleet Characteristics

A variety of vehicle types and sizes have been used to provide paratransit services ranging from passenger automobile to full size buses, vans, small buses, and manufacturer's conversion of motor buses. Figure 3-1 provides an estimate of the number of vehicles used for each of the paratransit services, independent of the vehicle mix. It is seen that the number of vehicles used in the conventional taxi fleet is an order of magnitude more than the combined vehicles used -- the other paratransit services.

3.1.4 Funding

There are a variety of funding sources for paratransit. Public, private, private non-profit, Federal, state, local sources are available. Carpooling is usually privately funded with the exception of some limited promotional activities. Vanpools are also privately funded, although there have been several governmentally funded demonstrations. On the other hand DRT is funded primarily through Federal monies. A GOA report in 1976 identified 114 different Federal funding sources. Figure 3-2 shows the percentages contributed by the major programs at that time. Interesting to note is that DOT is funding only 15 percent of all DRT paratransit and 60 percent of that must go to non-

TABLE 3-7. ANNUAL PASSENGER TRIPS (Millions)

	1975	1979 (Projected)	
Motor Bus	4,100	4,850	Conventional Transit
Rail	1,500	1,550	
Demand-Responsive	16.6 to 16.9	24.4 to 24.8	Paratransit
Conventional Taxi	3,104	3,300 to 3,500	
Ridesharing	No Data	16,000 to 20,000	
Ancillary to Social Agency Programs	60	150 to 210	

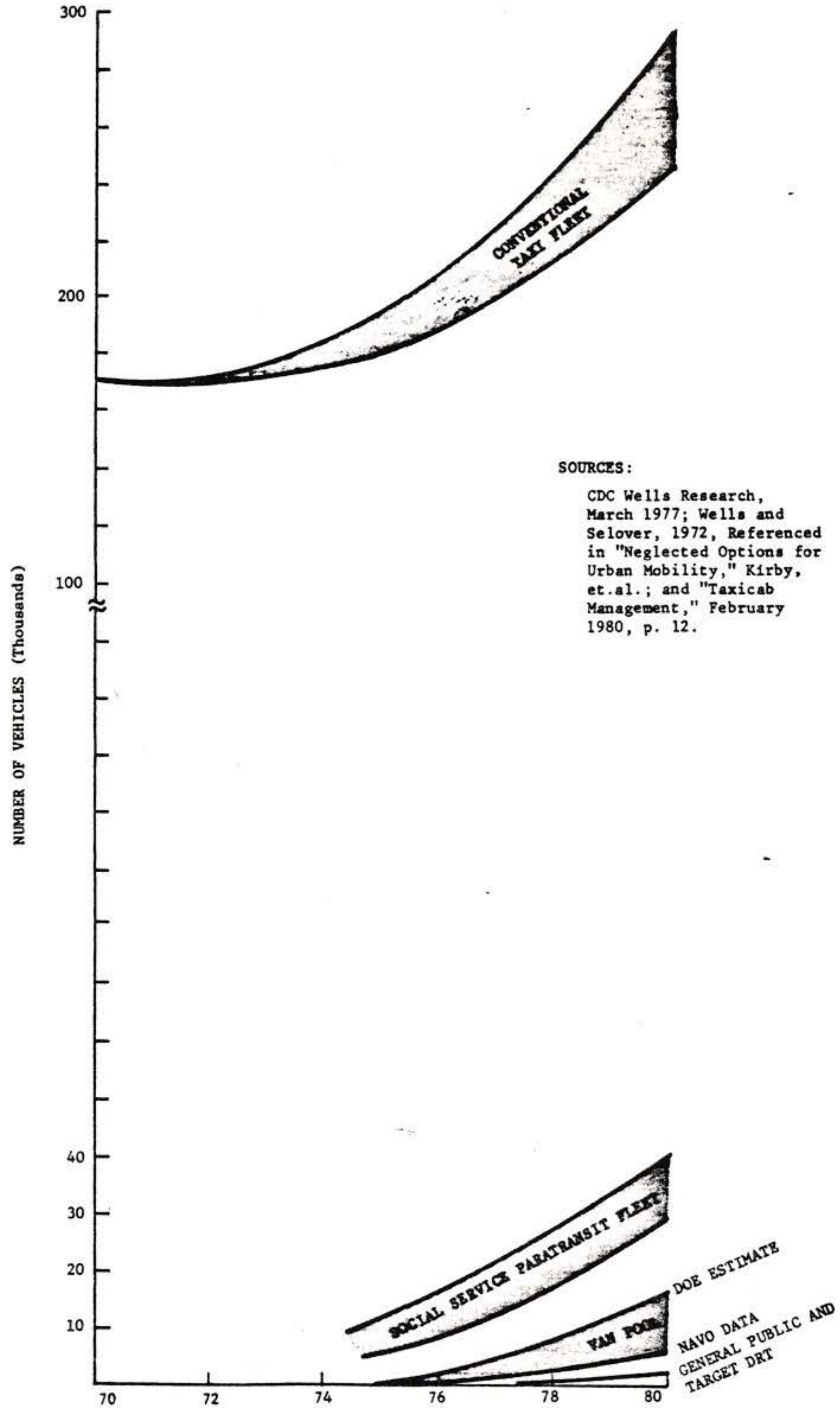
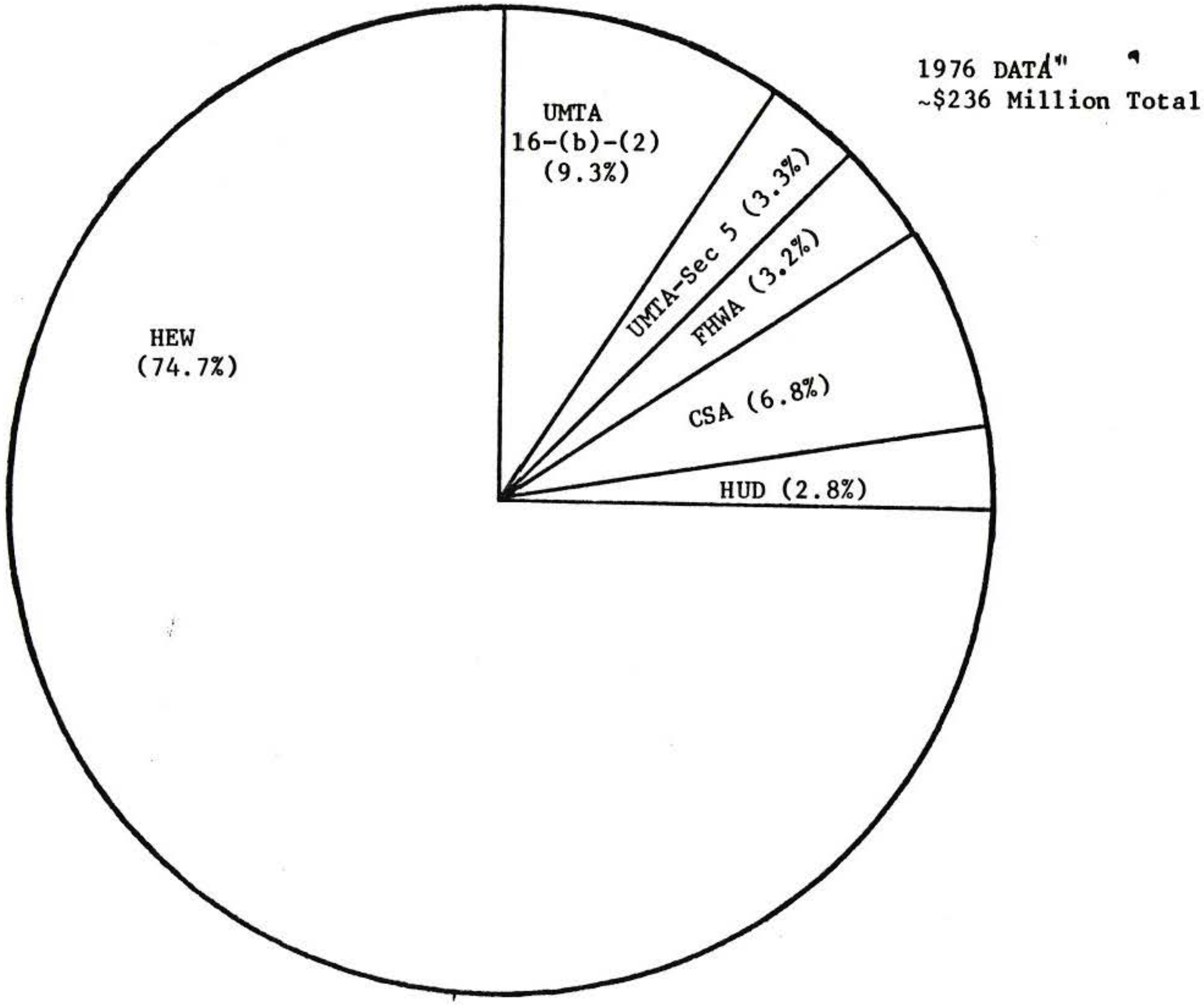


FIGURE 3-1. PARATRANSIT FLEET ESTIMATES



SOURCE: With modifications; "Hindrances to Coordinating Transportation of People Participating in Federally funded Grant Programs," Controller General of the United States, October 17, 1977.

FIGURE 3-2. MAJOR FEDERAL FUNDING FOR PARATRANSIT* profit agencies providing services to the elderly and handicapped. Based on updated information provided by HEW* the total dollars being spent is considerably larger. Estimates of 1980 funding range from a conservative $500 million to as much as $1 billion.

3.2 PROJECTION OF PARATRANSIT SERVICES

A number of studies have attempted to assess the future role of paratransit both as an independent service and as a service integrated with conventional fixed-route bus and rail systems. It was quickly recognized that paratransit is nowhere near as well defined, organized or monitored as other modes of transportation, specifically bus transit. Typically, past studies* encountered substantial difficulties in obtaining and aggregating data to define future roles or even to analyze the problem parametrically with any reasonable level of confidence. Major difficulties, which still exist today, are discussed briefly in the following paragraphs.

Data on various services comprising paratransit are almost non-existent. There are no aggregate nationwide data on paratransit fleet sizes, ridership, costs, labor employed and productivity. Whatever data that are available, primarily taxicab data and UMTA-funded DRT demonstrations, are either quite old or site specific and, therefore, difficult to generalize. Moreover, paratransit services, to date, have generally not demonstrated durability or stability to permit accurate generalizations. On the other hand, ridesharing, specifically carpooling and vanpooling, is relatively new; estimates (optimistic) are still speculative. Unforseen policy or regulatory changes (such as eliminating entry or exclusive-ride restrictions for taxis) might also have profound impacts on service levels and ridership.

The growth or alteration of urban areas in the future is difficult to predict. Significant changes in market forces that either worsen energy

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*Voorhees, A.M., "Study of Future Paratransit Requirements," for UMTA/DOT January, 1977;
Multisystems, Inc., "Benefit-Cost Analysis of Integrated Paratransit Systems," for UMTA/DOT, Sept., 1979.
Multisystems, Inc., "Paratransit Assessment and Directions for the Future," Draft Final Report, for UMTA/DOT, January, 1980.

availability or adversely impact other aspects of the economy may trigger new directions in development. Clearly, the accompanying travel patterns (and therefore, paratransit demand) will be dependent on whether or not urban areas continue to sprawl, high density areas experience revitalization, or satellite cities develop around the core city.

There is a great overlap and, in some cases, direct competition for ridership among paratransit service elements. Taxicab services, for example, provide substantial services for the elderly and handicapped as well as transportation associated with social services. This situation creates problems in estimating ridership according to type of trip or patron served. There are also numerous management and operating entities (private, public, contractual, volunteer, etc.) providing paratransit services. Operating cost information and arguably productivity and efficiency, as well, vary accordingly.

As a result of these difficulties and in light of the enormity of the problem, no novel scenario analyses were attempted in this study. However, for purposes of discussion some scenario projection data, developed in the referenced studies, are provided herein without any express or implied judgments on the validity of the approach of the credibility of the results.

The Voorhees study on "Future Paratransit Requirements" is a much-referenced study that attempted to project nationwide paratransit fleet characteristics for the future (1995). Typical urban areas were selected to form a representative range of settings from which aggregate values could be established. Paratransit service types, levels of service, and fare structure were envisioned for each setting. Judgments were made to estimate the magnitude of travel demand. Three future environments were devised which basically varied the price and availability of fuel as well as imposed auto restrictions. Projection data provided here are based on a moderate auto disincentive future which was based on a continuation of trends experienced during the post-oil embargo time period. This resulted in a 1995 environment with fuel prices rising to between $1.50 and $2.00 coupled with moderate auto restrictions. Nationwide fleet estimates resulting from this analysis are given in Table 3-8.

It is interesting to draw some analogy to our fixed-route analysis based on interpolating the data available from Voorhees. It is found that bus fleet

TABLE 3-8. PARATRANSIT STATISTICS

	VEHICLES PER 1000 PERSONS[2]		
	1975	1990[5]	1995
Conventional Bus Transit	0.3 (48,000 vehicles)	0.45 (81,000 vehicles)	0.5 (95,000 vehicles)
Paid Driver Paratransit			
Conventional Taxi	1.4 (224,000 vehicles)	1.18 (212,000 vehicles)	1.1 (209,000 vehicles)
DRT	--		0.8 (152,000 vehicles)
Preparranged E&H	--	1.0 (180,000 vehicles)	0.2 (38,000 vehicles)
Other Non-Transit Services[3]	0.3 (48,000 vehicles)		0.2 (38,000 vehicles)
Total Paratransit[4]	1.7 (272,000 vehicles)	1.28 (392,000 vehicles	2.3 (437,000 vehicles)

(1) Source: Voorhees, A.M., "Study of Future Paratransit Requirements, Scenario Report, Nov. 1976. 1975 urban population of 160 million; 1990 urban population of 190 million; 1995 urban population of 190 million used to compute fleet sizes.
(2) Includes 10 percent provision for spare vehicles.
(3) Includes such elements as airport ground transportation, volunteer transportation.
(4) Values for 1975 are plus or minus 10 percent; for 1995 plus or minus 40 percent.
(5) Values for 1990 are interpolated assuming linear growth from 1975 and 1995 data provided by Voorhees.

projections for 1990 in the Voorhees study fall between our Scenario II and III.

Voorhees data also indicate that from 1975 to 1990 the nation's bus system could expand 68 percent, while the total paratransit fleet increase is only 44 percent. Moreover there is a continuous reduction in conventional taxi vehicles with associated greater increase in other paratransit services. This reduction in conventional taxi fleet does not necessarily indicate a loss in overall capacity, rather it could indicate a shift of conventional taxi vehicles to shared-ride paratransit service.

Annual ridership estimates projected by Voorhees also indicate that from 1975 to 1990 all taxi and paratransit ridership could increase over 200 percent, based on the assumptions that the average paratransit vehicle will be larger and productivity will be much higher than today (as much as 2-3 times). The total number of trips for all road transit is estimated to more than double during this time period.

Understandably there are large potential errors in these estimates. Therefore, no further scenario analysis on paratransit was attempted. Suffice it to say for the purpose of this assessment, some attendant growth in paratransit service and ridership is expected in the next decade. Both paratransit and fixed-route are influenced by the same driving functions. Additional discussion of a more qualitative nature concerning current perceptions of growth areas for paratransit are provided in Section 4. Clearly, new data need to be obtained and analyzed to better understand the current role of paratransit and its potential future.

There are a number of issues that could seriously affect the paratransit role. Such issues include:

1) Given that Section 504 regulations are reversed concerning the accessibility of fixed-route service and changed to permit "increased special efforts" at the local level, what would the range of impacts be?

2) If many of the major Federal social service agencies looked to DOT to provide transportation related to their services, how would the role of paratransit develop in the next decade?

These types of issues together with the energy availability/price problems common to other modes must be identified and the implications on Federal RD&D requirements assessed.

3.3 INTEGRATION OF TRANSPORTATION SERVICES

Conventional fixed-route rail and bus systems may prove to be more effective when they are coordinated with paratransit services and automobiles to form an integrated transportation system. Among the facets of service which may be coordinated are geographical coverage, scheduling, management, fare collection, service utilization, equipment maintenance and institutional arrangements.

The objective of transportation coordination is to establish an urban transportation system where each mode is used where it is most appropriate. In a coordinated system, the function of each transportation mode - bus, rapid transit, commuter rail, paratransit, taxi, and automobile, is well defined. Each mode complements, rather than competes with the other. Multi-modal travel is facilitated through coordination of schedules, fares, and facilities. Intermodal terminals, platforms, and curbside stops would assure the passengers of quick and easy transfers.

Routes and schedules for fixed-route vehicles would reflect the changes in travel patterns and levels of demand for service that occur during the day. On demand paratransit services would replace fixed schedule services where demands were low, either geographically or temporally. Automobile intercept would be encouraged, both by increasing the attractiveness of transit vis-a-vis the automobile, using such techniques as dedicated bus lanes and bus priority systems, and by restrictive measures such as parking limitations.

By and large, transportation in the United States is only in the embryonic stage. Several large transit systems have separate fares for bus and rail (New York, Boston). Routes tend to follow the demand patterns for peak hour travel, and frequently fixed route service is maintained when demand responsive services could be more usefully introduced.

The vast majority of paratransit installations are not currently integrated with fixed-route service, but rather operate as stand-alone paratransit services in small communities.[1] Experience to date using paratransit as a local circulator/collector and feeder to line-haul transit (Haddonfield, Rochester, and La Habra) has been limited with no clear results. There have been some clear successes in Canada, particularly in Peterborough, Ontario, where shared-ride taxi service replaced a fixed-route service in a low density area. Daily ridership increased almost four times.[2]

Not all paratransit services lend themselves easily to coordination. Those that can be integrated are typically operated under a central dispatching control that assigns passengers to vehicles and dispatches vehicles to pick-up and drop-off points according to demand (i.e., DRT service). Coordination is most effective when paratransit is operating in a many-to-one or one-to-many service, rather than for scattered many-to-many demand which can be more effectively served by the automobile.

The increased ridership projected on this report will demand increased service penetration in low density areas. To provide an acceptible level of accessibility (distance to bus) and service (frequency) will result in exorbitant costs unless a coordinated approach is adopted. The commuter bus service in Reston, Virginia, located approximately 14 miles from Washington, D.C. is an example of effective coordination on a limited scale. Standard-size buses operate throughout the community as collectors. These meet at a specified time at which post passengers transfer to the bus appropriate to their destination. Buses then operate an express line-haul mode to different destinations in the metropolitan Washington area. However, at present there is no effort to tie in paratransit services for those areas where the demand is insufficient to justify services by a standard-sized bus.

Efforts to coordinate transit systems should be directed toward three areas which represent a categorization of the service parameters mentioned earlier:

a) The organizational structure under which the operators function (often called the <u>institutional</u> framework);

b) The service provided (often called <u>operational</u> framework); and

c) The facilities and equipment used (often called the <u>physical</u> framework).

An example of the instituional framework of coordination is the transportation broker. Experience in Knoxville has shown the benefits of a coordinated system of fixed-route fiscal schedule, subscription service, vanpools, and paratransit.

Coordination of interconnecting fixed-route bus or rail service with paratransit service is an example of operational integration. Lastly, the common use of terminals, dispatch equipment or maintenance/labor would be an example of physical transit integration.

In each area of transit service coordination more innovation and research are needed to determine those factors that result in success, as measured by increased ridership, and lower costs.

4. ROAD TRANSIT NEEDS AND ISSUES

4.1 PRODUCTIVITY AND COST, AND OPERATION & MANAGEMENT

Most of the analyses in this report have been based on data from the period 1976-1979, and, when extrapolated, have assumed that costs will only increase proportionally to increased service and the rate of inflation. However, experience suggests that this may have led to the operating costs being underestimated.

Transit operating costs increased by $2.4 billion (99 percent) during the period 1967-1976. Of this increase, approximately one half was due to inflation. However 28 percent ($680 million) was due to wage and fringe benefits over and above inflation. The recent tendency to include a cost-of-living escalator clause in contracts will only exacerbate this trend.[8]

Coupled with the increase in labor costs has been the decrease in labor productivity. Over the period 1960-1978, the number of employees per million revenue passengers increased from 19.8 to 28.4. In contrast, European systems typically have a ratio of 18 employees per million revenue passengers. The reduction in productivity accounted for 9 percent of the cost increases over the period 1967-1976.[9]

Obviously these trends must be reviewed if the operating costs projected in this report are to be achieved or reduced. Techniques for improving productivity described in this report are classified under:

- o vehicle design,
- o vehicle subsystem performance,
- o operating and support equipment,
- o operating practices, and
- o maintenance.

Productivity can be increased in two ways:

1. by taking steps to reduce the cost per passenger for a given ridership; and
2. by increasing the ridership for a given level of service.

This section concentrates on the former of these, although in practice it is likely that productivity improvements will be achieved through a combination of both.

4.1.1 Vehicle Design

Many vehicle design features can have a favorable impact in productivity. Table 4-1 lists a number of these, each with a qualitative assessment of the impact on productivity.

Three of the design features are identified as having the potential for a "significant improvement" in productivity:

- door width,
- seating capacity, and
- number of doors.

Three of the design features are identified as showing the potential for "improvement" in productivity:

- low floor,
- light weight, and
- seat design.

Door Widths

Most U.S. buses are designed with a door width that limits boarding or alighting to a single stream of passengers. Widening the doors to allow two streams of passengers to board and alight simultaneously results in a reduction of up to 40 percent in passenger service time. Passenger service time at each stop comprises two elements: a fixed dwell time, and a variable time that is determined by the number of passengers boarding and alighting. Wide doors can result in the variable element being reduced by as much as 50 percent, depending on the number of passengers; the mix of boarding and alighting, and the methods of fare collection used. In a typical in-town route in which passenger service time represents from 15 to 25 percent of the total travel time, the provision of wide doors can result in an overall travel time savings of from 4 to 10 percent. Schedule adjustments to take advantage of these savings will result in a commensurate improvement in productivity.[10]

TABLE 4-1. VEHICLE DESIGN FEATURES

Vehicle Feature	Area Affected	Anticipated Productivity Affect	Rating*
Floor Height	Passenger Service Time	Low floors increase boarding speed and thereby reduce vehicle dwell time particularly when E&H involved.	I
Acceleration	Travel Time	Recuction in time necessary to attain cruise speed--possible increased fuel consumption.	N
Acceleration	Delayed Time	Permits better opportunity for re-entering traffic flow--possibly increased fuel consumption.	N
Service Speed	Travel Time	Faster cruise speed to reduce travel time.	N
Door Width	Passenger Service Time	Wide doors permit simultaneous boarding and alighting and thereby reduce vehicle dwell time.	S
Climbing Ability	Travel Time	Increased climbing ability translates into increased average speed.	N
Number of Doors	Passenger Service Time	More doors provide easier access and egress thereby reducing vehicle dwell time.	S
Maneuverability	Delay Time	Enhances vehicle ability to compete with and maneuver in traffic congestion.	N
Aisle Width	Passenger Service Time	Increased aisle width decreases vehicle dwell time.	M
Vestibule Area	Passenger Service Time	Eases flow past driver and to passenger compartment.	M
Seating Configuration	Passenger Service Time	Different seating configurations (particularly reductions in seats) may reduce passenger service time.	M
Seat Design	Capacity	Compromise between seating and standing while maintaining comfort/safety.	I

TABLE 4-1. (CON'T)

Vehicle Feature	Area Affected	Anticipated Productivity Affect	Rating*
Door Controls	Passenger Service Time	Negative.	N
Seating Capacity	Capacity	Labor productivity improvement with longer (higher capacity) vehicle.	S
Ramp or Lift	Passenger Service Time	Negative.	**
Light Weight	Fuel Consumption	Reduced fuel costs.	I

*Estimate of potential magnitude of possible improvement: N = negligible; M = marginal; I = improved; and S = significantly improved.

**Providing a ramp or lift typically yields productivity degradation; designs can minimize the adverse effects of this feature.

Seating Capacity

Increases in seating capacity can be achieved through increasing the length (articulated) or height (double deck) of a bus. Both types are in limited use in the United States. A 50 percent increase in productivity in terms of passenger seating is achieved. A similar full load (seating plus standees) increase is achievable for the articulated bus, but not for the double deck bus, because, for safety reasons, standing is not permitted on the top deck.

Part of the increased productivity savings is offset by the increased fuel consumption and additional maintenance costs. Inadequate data are available to assess these increases. If it is assumed that they are proportional to the increase in capacity, the total productivity gain will be reduced to 20 percent. In addition, the increased loading will cause an increase in passenger service time--approxiamtely 10 percent under peak loading conditions. This results in a net productivity improvement of 10 percent.

Experience to date with double deck buses suggests that the relative inaccessibility of the upper deck does not have an adverse impact on passenger service time.[11]

Number of Doors

Experience has shown that passenger service time is decreased with an increased number of doors.[1] However, in a conventional bus, some reduction in seating capacity (4-8 percent) can result. In the case of articulated buses, an additional door will compensate for the increased passenger service time that results from the increased loading, and a net improvement in seated productivity will result of from 4-6 percent.

Low Floor

Measurements of boarding and alighting times on different designs of buses have shown little difference for buses with low floors, as far as the general population is concerned.[2] However, "slow boarders" and "slow alighters," due to infirmities, take, on average, 3-4 seconds longer to board, and 1.5 to 3 seconds longer to alight than the general public. After allowing for the percentage of this class of rider, average stop times increase between 0.1 and 0.3 seconds (approximately 2 percent) because of this. This particular segment of ridership will benefit most from the provision of low floor buses.

Light Weight

Current Advanced Design Buses weigh approximately 26,200 pounds when equipped with a lift; this increases to a seated load weight of 33,250 pounds. It appears feasible to design a bus with an unloaded weight of 21,000 pounds, with a seated load weight of 28,050. Performance simulations, assuming the same driveline efficiency, indicate a fuel savings of 8 percent over the current ADB.[10] This represents an operating cost reduction of slightly under one percent.

Seat Design

Alternative "seating" such as the "butt rest" demonstrated in the Advanced Concept Train will provide for increased capacity within the envelope of existing standard size buses. As in the case of high capacity vehicles, part of the productivity improvement obtained by increased capacity will be offset by the increased passenger service time.[1]

4.1.2 Vehicle Subsystem Performance

Vehicle subsystem performance affects productivity mainly through reduction in fuel consumption. At present, fuel accounts for approximately ten percent of transit operating costs.

Engine

Current ADB buses are equipped with a Detroit Diesel Allison two cycle 8V71 diesel engine. Fuel consumption varies according to type of service, but can be as low as 3 miles per gallon. A figure of 3.5 miles per gallon is more typical.

Detroit Diesel has recently introduced a six cylinder (6V92TA) diesel engine. This is claimed to have a higher brake horse power and higher torque than the current engine. A 7 percent reduction in fuel consumption has been claimed. This would result in a cost saving of something less than one percent.[10]

European buses claim fuel consumption of the order of 6 miles per gallon, although these are not equipped with air conditioning. Assuming a 20 percent penalty for air conditioning results in a fuel consumption of 4.8 miles per gallon which is still a 37 percent improvement over ADB or a 3.7 percent improvement in operating costs).[10]

Transmission

An Allison VT30 transmission is standard on ADBs. Introduction of a 4-speed (versus 3-speed) transmission, improved drive train control, and improved drive line lubricatns may yield up to a total of 10 percent improvement in efficiency--or a 1 percent reduction in operating costs.

Engine Cooling

One transit system has experimentally modified the cooling system of the bus, including fitting a smaller fan, and claims a fuel savings of 25 percent.[3]

The cooling system represents a significant load on the engine (under some conditions as much as 15 percent of the power output), and a more sophisticated type of fan could possibly lead to reduction in fuel consumption.

Air Conditioning

Air conditioning imposes a penalty of approximately 20 percent in fuel consumption. Currently, all ADBs operate with sealed windows, requiring the use of air conditioning, heating, or air circulation systems at all times.

Considerable fuel savings would result from limiting air conditioning to those sites with high heat/humidity for more than 5 percent of the year, and by providing un-powered air circulation systems such as opening windows and roof air vents.

Energy Storage

Energy storage systems are based on the storage of the kinetic energy normally discipated as heat when a bus is braked. This energy is retained during the acceleration and coast cycles. Since bus engines are required to generate maximum power during acceleration, some reduction in engine size is permissible. The engine can also operate at an approximately consistant speed and it is also more efficient.

The main thrust at present is on flywheel energy storage. However, an experimental hydraulic energy storage system is being developed for automobiles, and has been proposed for buses. Savings of up to 50 percent in fuel consumption have been claimed.[12]

4.1.3 Operating and Maintenance Support Equipment and Facilities

Table 4-2 lists a number of operating and support equipment facilities and features that could have an impact on productivity. Six of these have been identified as resulting in "improved" or "significantly improved" productivity:

- o Automatic Vehicle Monitoring,
- o Bus Priority Equipment,
- o Computerized Run Cutting and Scheduling,
- o Improved Management Techniques,
- o Improved Fare Collection, and
- o Automatic Information Systems.

4.1.3.1 Automatic Vehicle Monitoring - Automatic Vehicle Monitoring is currently being demonstrated in the United States, in Los Angeles, California. This technique has also been used in Europe, in major cities such as Dublin, Paris and Hamburg.

Three benefits of automatic vehicle monitoring are identified in Table 4-2, as resulting in "significantly improved" productivity:

- o schedule adherence,
- o headway control, and
- o load leveling.

Schedule Maintenance

Improved schedule adherence will benefit productivity in two ways:

1. It will reduce the number of checkers required, and the associated costs.
2. It will result in a reduced layover time.

Since automatic vehicle monitoring replicates many of the functions of the street checkers, it is possible to reduce the number employed with a level required to handle only emergency situations. One analysis has indicated that the number of street supervisors can be reduced to one third, representing a savings of approximately 5 percent in total operating cost.[13]

TABLE 4-2. OPERATING AND MAINTENANCE SUPPORT EQUIPMENT AND FACILITIES

Feature	Area Affected	Anticipated Productivity Effect	Rating*
Automatic Vehicle Monitoring	Schedule Maintenance	Fewer checkers required.	S
		Reduced layover time.	S
-	Headway Control	More even distribution of passengers--fewer buses required at peak (open loop).	S
-	Load Leveling	Passenger counter data allows schedule adjustment (closed loop).	S
-	Public Safety	Reduces losses due to robbery.	M
Bus Priority at Signalized Intersections	Travel Time	Increases average speed.	S
		Smaller schedule deviations.	S
Computerized Run Cutting and Scheduling	Vehicle Miles	Improved vehicle.	S
	Platform Hours	Operator productivity.	S
Improved Management Techniques	Planning	Improved response to short-term changes.	I
	Resource Allocation	Elimination of low productivity runs/routes.	I
Fare Collection	Passenger Service Time	Reduction in dwell time--higher average speed.	S
Automated Information System	Passenger Information	Reduction in cost of providing passenger information.	I
Early/Late Display	Scheduled Maintenance	Reduced schedule deviations.	M

*Estimate of potential magnitude of possible improvement: N = Negligible; M = Marginal; I = Improved; and S = Significantly Improved.

Improved schedule adherence leads to reduced layover time becuase the reduction in standard deviation allows for a commensurate reduction in the "slack time" at layover points. The previously referenced study indicates savings in the range of 3 to 10 percent of total operating cost, resulting from a reduction in the layover time.

- Headway Control and Load Leveling

These two benefits are combined since they represent different approaches to minimizing the number of buses required to serve a given demand. Headway control is an open-loop approach; load leveling a closed loop approach to maximizing the productivity of vehicles. Most attention has been paid to headway control to date; load leveling (or dynamic scheduling) is an innovative approach that needs to be developed and demonstrated before it can be considered an operational tool.

Headway control is the equivalent of schedule maintenance, but for routes with short headways. It attempts to equalize loadings between buses by controlling them so they are a fixed time apart (rather than keeping to a fixed schedule). This approach minimizes the incidence of fully loaded buses immediately followed by buses that are carrying few, if any passengers. The previously referenced report[13] indicated a saving of between 1 and 10 percent for vehicles operating with headways closer than 10 minutes.

Load leveling is an extension of this technique in which the time between buses is adjusted according to their actual loading and the predicted arrival of passengers at bus stops. Theoretically it would provide the highest level of productivity improvement. Whether it would, in fact, show a significant savings over headway control would have to be determined by a demonstration under operational conditions.

4.1.3.2 Bus Priority Equipment - Bus priority equipment allows high capacity vehicles to override the normal sequence of signalized intersections, either by truncating the red or extending the green sequence. The object is to minimize the delays experienced by a bus due to adverse signal conditions. Some of the earliest experimentation in bus priority systems was performed in Washington, DC. Simulations results have indicated time savings varying from 12 to 31 percent.[14] Equally important, the standard deviation of travel time around the mean was reduced. Measurements of the system in operation showed "bus travel" time savings greater than 10 percent.[15]

Similar resuls were achieved in a demonstration of bus priority treatment on N.W. 7th Avenue in Miami, Florida. Time savings varied between 10 and 25 percent.[5]

4.1.3.3 Computerized Run Cutting and Scheduling (RUCUS) - The improvement in productivity achievable with RUCUS, now in use in more than 40 transit systems, depends to a considerable extent, on the experience of the scheduling department, and on union contracts. In practice, RUCUS has shown up to 3 percent saving in total operating cost, and up to 5 percent in the total number of drivers required.[16]

4.1.3.4 Improved Management Techniques - Improved management techniques are essential if productivity is to be increased, but transit systems, in many instances, have been slow to accept and use management techniques that are common on both the private and public sectors.[7]

For example, Seattle METRO measures productivity in terms of passengers per trip (at the maximum load point) and passengers per bus hour, in both peak and off peak periods. Seattle is experimenting with automatic passenger counter equipment, to establish whether the necessary information can be obtained more economically and accurately than with manual checkers.

Some of the information that can be obtained from an automatic vehicle monitoring system for subsequent use in a management information system, is listed in Table 4-3.

Monitoring of existing and new services has been specifically identified as a tool for productivity improvement.[17]

4.1.3.5 Improved Fare Collection - Conventional fare collection using exact fare on one-man-operated buses results in a significantly longer passenger service time than when off-board fare collection is used. Boarding time is typically 3.5 seconds per passenger compared to approximately 1.5 to 2 seconds per passenger for off-board fare collection.

"Detailed computer analyses, using data from existing types of U.S. bus

TABLE 4-3. MANAGEMENT INFORMATION INPUTS FROM FROM AUTOMATIC VEHICLE MONITORING SYSTEMS

Passenger Counts:
o Optimal Scheduling
o Section 15 Requirements
Performance of New Routes (Schedule and Ridership)
Improved Maintenance Scheduling
Improved Finance and Accounting:
o Allocation of costs/revenues by:
- Route
- Time of Day
- Political Subdivision

routes, indicates an improvement in transit speed of 6 to 8 percent (with off-board fare collection.)...A high proportion can be achieved without substantial changes in the characteristics of transit buses operated."[4]

Total elimination of on-board fare collection would provide:

- o fuel economy improvements of up to 5 percent,
- o on-board accident claims reduced by 40 percent,
- o trip speed increased by more than 6 percent, and
- o operating costs decreased by 6.2 percent (with free fare approach).

Several studies[2,4,18] show effects of different fare collection procedures on passenger service time including:

- o pay enter versus pay leave,
- o exact fare versus change,
- o flat fare versus multiple zone, and
- o farebox versus fare receipt.

Automatic Passenger Information Systems

Telephone information systems are a prime source of information for potential bus riders, but costs of handling calls can be as high as $1.00 or more per inquiry, and a large system can handle in excess of one million calls per year. Techniques for improving productivity vary from providing suitable manual retrieval equipment for the information operator[19] through computer information retrieval systems[20] to a fully automated system, with a caller receiving a computer generated voice response.[21] A concept of a semi-automated information system capable of handling over 50 percent of all calls received has recently been suggested.[22] Handling inquiries can amount to up to two percent of a transit system's budget. Automating part of the system could save approximately half of this.

4.1.4 Operating Practices

Operating practices that will be reviewed include:

- o part time labor,
- o transportation systems management, and

o mixed fleet operation.

4.1.4.1 Part Time Labor - One method of reducing operating costs is the introduction of part time labor to handle the operating peak, particularly drivers. Recently five major transit systems have been successful in introducing part time labor.

A recent survey showed that 53.3 percent of all systems surveyed and responding used some form of part time labor[23], however,

(a) Use of part time labor tended to be concentrated in the small systems. Part time labor is being introduced in large systems to accommodate system expansion, but with some limitations. For example, WMATA is limited to 10 percent of all operators; Seattle to a maximum of 600. WMATA expects to save approximately $1.8 million dollars a year (about 3 percent of bus operating costs).[24]

(b) CITRAN (Fort Worth) claims cost savings[17] of 15 to 20 percent of the costs of operating in the peaks.

(c) It is not possible to determine what this represents as a percentage of total operating costs.

4.1.4.2 Transportation Systems Management - Transportation Systems Management strategies fall into five basic categories:

1. Mandatory Usage Controls,
2. Economic Controls,
3. Transit Operations Modifications,
4. Minor Supply Additions, and
5. Demand Modification

Examples to illustrate each of these categories are given in Table 4-4.

Table 4-5 is an expanded list of strategies resulting in preferential treatment of high occupancy vehicles. The impact of one form of preferential treatment is shown in Table 4-6, which demonstrates the impact of a number of preferential bus/car pool lanes.

TABLE 4-4. EXAMPLES OF TRANSPORTATION SYSTEM MANAGEMENT STRATEGIES

Strategy	Implementation
Marketing Usage Controls	
Crossing Control	Bus priority signal system
Entry Control	Preferential entrance ramps
Lane Usage Control	Preferential lanes
Curb Control	Parking restriction
Parking Control	Preferential parking for pool cars
Pricing	
Road Pricing	Congestion pricing
Parking Pricing	Differential parking price for pool cars
Transit Pricing	Peak and mid-day fare differentials
Supply Augmentation	
Transit	Subscription bus service
Street	Bus loading bays
Paratransit	Ride-sharing
Parking	Suburban park and ride facilities
Demand Modification	
Time Distribution	Flexible work hours
Frequency	Telecommunication substitution
Spatial Location	Land use changes

TABLE 4-5. PRIORITY FOR HIGH OCCUPANCY VEHICLES

Freeway	
1.	Exclusive and separated lanes
2.	Exclusive but not separated lanes
3.	Single lane in contraflow direction
4.	Separate access ramps or other "queue jumping" techniques
Major Arterial	
1.	Single lane in contraflow direction
2.	Restricted lane (curbside)
3.	Intersection signal preemption
CBD Street	
1.	Restricted lane (curbside)
2.	Contraflow lane (curbside) on one-way street
3.	Bus-only streets
4.	Exemption from left turn restrictions
5.	Intersection signal preemption
Miscellaneous	
1.	Exclusive lane at toll plazas
2.	Reduced toll charges
3.	Preferential parking locations and/or rates

TABLE 4-6. PERFORMANCE OF SOME BUS/CAR POOL LANES

Project	Vehicle Occupancy People Per Vehicle		Thruput AM & PM Peaks Combined		Travel Time Saved Minutes Per Trip
	Before Project	During Project	Before Project	During Project	
Shirley Highway	1.33	12.1	ND	30,500	20-23
Boston Freeway	1.35	1.44	23,600	21,600	14
Santa Monica Diamond Lanes	1.23	1.34	138,900	136,400	6-7
Miami I-95	1.23	1.28	18,600*	23,800*	3
San Bernadio	ND	6.25	1,800	17,000	15-18

*Thruput for AM peak only
ND = No Data Available

4.1.5 Maintenance

In addition to the improved management techniques referred to earlier, the following maintenance techniques appear to offer the potential for productivity improvement:

- o diagnostic equipment,
- o oil check program,
- o dynamometers,
- o brake testing, and
- o spectrochemical oil analysis.

Diagnostic Equipment

Automatic diagnostic equipment has proved successful for truck operations, and a demonstration of its application to diesel buses is now being conducted. Extensive use of this technique will require that consideration be given to installing the appropriate transducers at the time of bus manufacture.[25]

The degree of detail achievable depends to some extent on the effort employed in instrumenting the vehicle. For example, when dealing with the fuel system it is possible to measure the peak injection pressure at the fuel delivery valve, and to compare the pressure at each injection in sequence determine whether one or more are outside predetermined limits. On the other hand, by inserting a transducer at the injector itself it is possible to isolate such factors as:

- o leaking injector,
- o timing,
- o sticking or broken valve or spring,
- o sticking needle,
- o coked nozzle, and
- o scored valve or seat.

Checks can also be made relatively simply on correct thermostat operation, on the operation of the starter, and on the air or vacuum systems.

Oil Check Program

At one transit property, maintenance crews were instructed to check the oil in each coach before starting each engine, instead of checking after the engine had been stopped for 3 to 5 minutes. As a result, oil use (excluding oil changes) dropped to 25 percent of its original level.[17]

This is an example of how a simple procedure change can result in a clearly desirable cost reduction.

Dynamometers[26]

Dynamometers used in transportation take two forms: engine and chassis. They both have the same function, to absorb the energy generated by the engine under various loads and under controlled testing conditions. However, an engine dynamometer tests an engine when it is physically removed from the vehicle (such as after a major overhaul), whereas a chassis dynamometer tests the engine while it is still in the vehicle. The vehicle is placed with its drive wheels located on rollers. As these rollers are turned by the wheels (which are being driven), they are retarded through the use of hydraulic or electrical (eddy-current) brakes.

Data on rpm, torque and horsepower are recorded on strip chart recorders. Accuracies of measure of 1/2 percent for torque and 1 percent for speed and horsepower are normal. Commercial units are available which will absorb up to 5000 HP, and which will handle speeds up to the equivalent of 85 mph.

When used with an accurate fuel flowmeter the dynamometer can be used by dynamic tune-ups, and also to provide a check on the quality of workmanship in the maintenance department. The equipment can be used for engine brake-in under load conditions, for checking automatic monitoring exhaust emissions under load conditions.

Brake Testing Equipment

Brake testing equipment provides for the static testing of braking systems. The vehicle is located with a pair of wheels located on a set of rollers driven by motors at a constant speed (typically 2.5 or 5 mph equivalent). As the brake pedal is depressed the braking force for each wheel is displayed, and may also be automatically plotted in a strip chart.

The system is arranged so that, as slippage occurs between the wheel and the driving rollers, power is automatically cut off to prevent damage to the tire. The system can also be arranged to include a measure of oeprating force (pedal force).

Brake problems account for 10 percent of all road calls. On average, a bus will require a road call because of brake failure at least once each year.

Spectrochemical Oil Analysis

Spectrochemical oil analysis, a proven technique for detecting incipeient failures in diesel engines, is already in limited use in the transit industry.[27] One transit system increased the oil change period from 6000 to 12,000 miles following the intruduction of spectrochemical oil analysis. Experience in the Air National Guard has shown a 50:1 payback.[28]

4.1.6 Conclusions

The potential productivity improvements described in this section are summarized in Table 4-7. However, great care must be exercised when considering the magnitudes of the savings possible, since these are predominantly system and route specific. For example, a productivity improvement of 10 percent can be achieved by the introduction of high capacity vehicles--but only where passenger demand is sufficiently high that replacement of standard vehicles by high capacity vehicles will not result in an unacceptable increase in headways. Similarly, the introduction of wide doors will only be effective on those routes where a significant number of stops have a large number of boarding or alighting passengers. Because of this, it would be desirable to conduct a number of demonstrations to determine the impact of these features on overall productivity, before encouraging their widespread use, either through specification, regulation, or price offset.

4.2 SERVICE QUALITY AND AVAILABILITY

In many respects, the needs perceived by transit riders are diametrically opposed to those of the transit industry. Riders would like frequent, reliable, understandable service, available throughout metropolitan areas, provided with low fares and with little or no subsidy. Transit operators often perceive their needs as carrying the maximum number of riders at the lowest

TABLE 4-7. POTENTIAL PRODUCTIVITY IMPROVEMENTS

Class	Description	Rate of Savings	Remarks
Vehicle Design	Wide Door	4 - 10%	High-Demand Routes
	High Capacity	10%	High-Demand Routes
	Extra Doors	4 - 6%	Articulated Buses
	Low Floor	1%	Depends on Handi- capped population
	Seat Design	1%	Depends on Demand
	Light Weight	1%	Depends on Fuel Cost
Subsystem Performance	Engine	0.5- 3%	Depends on Route
	Transmission	1%	Improved Transmissions
	Engine Cooling	2%	Based on Very Limited Experience
Energy Storage	Air Conditioning	2%	Depends on Climate
Operating and Support Equipment and Facilities	A.V.M.	1 - 2%	Operational Improvement Only
	Bus Priority Equip.	10 -25%	Limited Selection of Route
	R.U.C.U.S	3%	System Wide
	Impr. Mgmt Tech.	20%	Various Approaches
	Impr. Fare Coll.	1 - 10%	Depends on Bus Loading
	Auto. Info Systems	2%	Depends on Degree of Automation
Operating Practices	Part-time Labor	1 - 5%	Depends on Union Agreement
	T.S.M.	1 - 20%	Highly Local-Dependent
Maintenance	Diagnostics	5%	Based on Truck Exper.
	Oil Check Proc.	10%	Based on 1 System
	Dynamometer	2%	Assuming 20% Improve.
	Brake Testing	1%	Reduction in Road Call
	S.O.A.P.	1%	Based on Engine Failure

capital and operating cost. As a result, transit systems concentrate on the segment of the market that is easiest to service - the journey to work. Routes and schedules are a compromise between ridership and costs. To an ever increasing degree, staffing and funding limitations inhibit the development of new markets and the expansion of new service. Nevertheless, the needs as perceived by the current, and more importantly the potential, transit riders must be taken into consideration if a major increase in ridership is to be achieved.

Few, if any, factors have such an impact on the acceptability of mass transit service as reliability. Ridership surveys consistently list reliability, in terms of on-time performance, as one of the top priorities. Contemporary bus operations are subject to delays due to bad weather, traffic and other road conditions, and equipment failures. Schedules, on the other hand, are based on historical rather than current performance.

Transit industry efforts to maximize system performance have frequently resulted in complex route structures and schedules. While many attempts are being made to simplify both, there is a continuing need to provide for higher quality information at lower cost. With projected ridership increases approaching 100 percent over this decade, it is essential that communication not be a barrier to this growth.

Service quality for a significant portion of the potential market, the ambulatory-impaired, but not wheelchair confined, also means improved assessibility in boarding and alighting from road transit vehicles. The over 65 year old group (though not necessarily all mobility impaired) is expected to increase in size from 23 million in 1976 to 32 million by 2000. Current designs of 8 to 10 inch step height and "high" floors present barriers to some degree to easy access for people with infirmities.

A basic fact that can't be overlooked is that for road transit demand to increase the service must be available. By today's standards, five minutes walk time, approximately a quarter mile, is generally considered the maximum distance for transit availability. The desirable population density for fixed-route scheduled service is about 8000 persons per square mile. However, average population density of urban areas in the U.S. decreased from 6500 in 1920 to under 4000 persons per square mile in 1978. To meet the demand for service under these conditions, novel systems, such as demand responsive services, must be deployed. Yet, though these services meet availability (or coverage) needs, they suffer from unreliability and high vehicle-hour costs.

The goal for the next decade is, therefore, to provide sufficient service capacity and service reliability to effectively and efficiently meet the emergency ridership demand.

4.3 ISSUES ON PETROLEUM/ENERGY CONSERVATION

It is estimated that total motor bus diesel fuel consumed in 1980 will approach one half a million gallons*. The average price per gallon that the nation's fixed route transit systems paid for No. 1-D diesel fuel increased to about $.80 at the end of 1979. This represents a 450 percent increase since 1970. During the next decade, vehicle miles will increase substantially in response to increased service demands and proportionally larger fleets. Based on the probability that fixed-route, road transit in the U.S. will approach the environment of Scenario III, there most likely will be a doubling of fuel consumption by the end of this decade.

Early in the 1970s fuel costs represented between 2 to 4 percent of the total annual operating cost for conventional bus transit. By 1980 fuel costs will climb to 10 percent or more of the annual budget. Depending on driver wage levels for paratransit, fuel could represent in excess of 10 percent of total operating costs in that mode as well.

Fuel availability for the fixed-route element of road transit appears not to be a problem due to the U.S. Department of Energy's indefinite extention of Special Rule #9 guaranteeing that transit systems receive 100 percent of the diesel bus fuel they need. Many paratransit services are not currently covered under this edict, however, and face difficulty in obtaining necessary fuel during times of shortages. It appears that the taxi industry comes under the umbrella of "public passenger transportation" for which fuel availability is guaranteed. However, there still remains the question of whether allocations are based on past experience or some estimated level of incremental level of increased vehicle miles.

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*Based on APTA trend data.

The rate of consumption, the spiraling increase in fuel costs, and the potential availability problems emphasize the need to reassess and deploy energy conservation and efficiency initiatives for urban road transit. The proper perspective of conservation is to provide public services as effectively and efficiently as possible to reduce private auto use, which accounts for more than 48 percent of annual petroleum consumption in this country.

As shown in Tables 4-8 and 4-9, public transportation accounts for an extremely low proportion of both total and urban travel. All transit modes combined serve only 2.9 percent of urban passenger-miles with the remaining 97 percent served by automobiles. The transit also serves only 7.8 percent of urban passenger, peak-period miles. Of that, fixed-route bus accounts for approximately 4 percent. Hence to affect transportation energy and petroleum demand significantly, public transportation must:

a) increase its share of total urban travel above its present 2.8 percent; and
b) increase its share of the urban work trip market above its present 7.8 percent.

Figure 4-1 provides the perspective for many energy conservation means for urban passenger road trips through improvements in public service efficiency and road transit vehicle systems. Within the service efficiency improvement, it is further broken down into intra-mode service improvement and intermode service improvement.

Simply stated, intra-mode service improvements concern each road transit element independently and have the objective of maximizing the number of passengers carried per unit of service provided (usually vehicle-mile or vehicle-hour) whereas inter-mode service improvements examine the trade-offs in carrying passengers and encourage the most energy efficient mode despite institutional barriers. The various areas that need to be considered in the resolution of the service efficiency issue are listed in the figure.

TABLE 4-8. PASSENGER-MILES OF TRAVEL (1972)

	Urban Travel (Local)		Total Travel (on ground)	
	$(10)^6$	%	$(10)^6$	%
Auto	1,248,461	97.1	2,171,332	97.0
Bus transit	23,355	1.8	48,955	2.2
Urban rail	(9,198)	0.7	13,638	0.6
Commuter rail	4,121	0.3	4,121	0.2
TOTAL	1,285,117	100.0%	2,238,046	100.0%

(Source: Energy Effects, Efficiencies, and Prospects for Various Modes of Transportation - NCHRP Report 43, 1977.)

TABLE 4-9. DAILY WORK COMMUTER PASSENGER-MILES (1975)

	(000)	% of total commuter travel	% in category
Drives alone	367,606	65.0	70.4
Carpool	154,450	27.2	29.6
Auto	522,056	92.2	100.0%
Bus/streetcar	22,000	3.9	50.1
Rapid transit	11,780	2.1	26.8
Commuter RR	9,892	1.7	22.4
Taxi	295	0.1	0.7
Transit	43,907	7.8	100.0%
TOTAL	565,963	100.0%	

(Source: Survey of Travel to Work-Supplement to the 1975 Annual Housing Survey (National), U.S. Bureau of the Census, 1978.)

PETROLEUM/ENERGY CONSERVATION

- SERVICE EFFICIENCY IMPROVEMENTS
  - INTRA-MODE IMPROVEMENTS
    - Operational Efficiency of Fixed-Route Bus
    - Service Extensions (Both Fixed-route and Paratransit)
    - Alternate Vehicle Sizes to Fit Demand
    - Bus Priority Strategies
    - Better Utilization of Taxi Resources
    - Ridersharing Incentives Drive alone Disincentives
  - INTER-MODE IMPROVEMENTS
    - Utilization of Paratransit on Lower demand Routes (spatial)
    - Utilization of Supplemental (Jitney/Taxi) Service for Fixed-Route Peak period service
    - Encourage Cooreination/Brokerage
    - Integration of services according to service demand (temporal)
- VEHICLE SYSTEM IMPROVEMENTS
  - REDUCED PETROLEUM CONSUMPTION
    - Engine Efficiency Improvements
    - Driveline Efficiency Improvements
    - Accessory Efficiency Improvements
    - Energy Recovery Systems
  - PETROLEUM-INDEPENDENT
    - Substitute Fuels (On-board)
    - Electric (On-board)
    - Electric (Wayside)
    - Hybrid

FIGURE 4-1. ENERGY CONSERVATION OF ROAD TRANSIT

4.3.1 Vehicle System Improvements

Although the absolute amount of potential fuel savings due to vehicle efficiency improvements is not substantial in relation to the national picture, it is improtant as an increasing element of the operating costs for transit properties. It is entirely probable that by the time No. 1-D diesel fuel reaches $2 per gallon, fuel costs will represent an average of 20 percent of the transit operating budget. Clearly, any fuel savings will help reduce Federal operating subsidy and the operating deficit. Representative areas associated with the vehicle where efficiency improvements potentially could be made are given in Figure 4.1. Often improvements are possible not only by new designs but through retrofit applications as well.

In the area of Petroleum independent improvements, considerable research is on-going for substitute fuels for the internal combustion engine primarily associated with the automobile. Such investigations must be tailored somewhat for application to transit coaches and the diesel engine. Modification or retrofit kits should be developed, if possible, to permit the use of substitute fuels in transit coach diesel engines. With diesel fuel costs increasing and concern over diesel engine emission mounting, a new look should also be given to considering (Hybrid) trolley bus in the near term as a petroleum efficient transit source for high density corridors.

4.4 REGULATORY AND ADMINISTRATIVE REQUIREMENTS

Legislation, regulations, and administrative requirements at the Federal, state or local level, applicable to road transit operations, are promulgated generally, for the promotion of public welfare. More specifically, such legal requirements are intended to promote or ensure safety, air quality, fair competition, service equity, reduce congestion or promote other national objectives. Although it is difficult to argue against such social objectives, it is important to continually assess how effective the associated requirements have been at approaching their stated objectives and (most important) at what cost. The following issues address this concern in more detail.

a) Regulatory Obsolescence. The regulatory process needs to be rigid in certain areas, particularly where experience has shown a definite and lasting need, the objective is acceptable by virtually all parties concerned, and continual uncertainty would only cause instability in production and deployment. Good examples in the road transit safety area are flammability of seat material and bus braking distance requirements. However, there are other requirements that may not possess universal acceptance and do not pass the "test of time", that is, although the requirements appeared reasonable and justifiable when they were issued, their continued application creates disadvantages out of proportion to anticipated benefits. Examples that appear to fit into this category include: the requirement for environmental impact statement for Section 5 operating assistance; administrative procurement requirements such as the low-bid process and the use of offsets; and numerous state regulations concerning axle loading or minimum vehicle widths. The operating environment as well as social pressures influencing road transit are continually changing and so too should many of the governmental controls.

b) Objectives with Conflicting Impacts. Unformtunately, actions taken to comply with one regualtory or administrative requirement often have adverse impacts on other governmental objectives. Clearly, mandating emission standards has adversely affected fuel efficiency and life cycle costs, and mandating full accessibility for the handicapped on fixed-route buses seriously increases operating costs. Thorough consideration of the attendant impacts is needed either before advocation or quantitatively after promulgation.

c) Selective Use of Regulatory Process. It has been argued that UMTA as well as other Federal and state agencies have been too heavy handed in controlling vehicle design, operating policies and funding conditions. In recognition of the validity of this argument, there has been at least some jawboning indicating agreement with the removal of burdensome requirements that are unnecessary by today's standards. However, universal or arbitrary abandonment of control is equally imprudent. Selected areas that need attention, such as vehicle maintenance, vehicle refurbishment, and rehabilitation of facilities, may continue to require control or even warrant intensifying certain requirements.

It is expected that in the next decade more decision making will be delegated to the local level with a corresponding reduction of cost-ineffective regulatory and administrative requirements.

4.5 SUPPLY INDUSTRY AND CAPITAL COSTS

Urban bus transportation is plagued by a number of critical problems associated with transit equipment supply. These problems seriously impact the capability of the Nation's transit operators to respond to emerging ridership demands and impair the effectiveness of Federal and local capital support which totaled about $600 million and $150 million, respectively, by the end of the 1970s.

Increasing Federal involvement since the Urban Mass Transportation Act of 1964 has resulted in a situation where public transit authorities are almost universally dependent on the eightly percent Federal share for their vehicle and facility procurements. Consequently, the lack of a clear, consistent Federal policy and funding structure during the early and mid-1970s caused indecision and delay in placing the required new vehicle orders. Federal Government policy creates and dominates U.S. market for road transit vehicles and associated products.

The vehicle procurement time from preliminary application in the local approval process through to the delivery of the vehicle can take anywhere from 11 to 30 months. There are at least three entities responsible for the entire process: 1) the local bureaucracy in their planning/approval process; 2) the Federal bureaucracy with the structured grant application red tape; and 3) the vehicle supply industry with a build-to-order philosophy and production backlogs of 45 to 52 weeks.

The price of standard city coaches increased more than 150 percent from 1972 to 1978 while inflation for the same period increased slightly less than 60 percent. It appears that at least partial blame for the increase in price in actual dollars can be placed on the increase in governmental regulations and administrative requirements and the extent of non-standard items requested at the option of the grantee.

At present approximately 28 percent of the Nation's fleet is 12 years and older.

Out of the approximately 52,000 vehicles, about 37,500 to 40,000 vehicles are used to meet peak hour demands. The reserve of 8300 to 9500 vehicles are older vehicles that are not expected to hold up if pressed into regular service. It follows that using a 12- to 14- year vehicle life, annual order rates of 3600 to 4200 are needed merely to sustain the fleet at its present level.

In order to facilitate the growth in the Nation's road transit fleet to 80,000 vehicles in the next decade, steps need to be taken to maintain a stable domestic supply industry. In addition, to provide the financial assistance, it is also necessary to eliminate the unproductive, adversary environment between the private and public sectors restricting a new relationship with common goals more in line with changing economic times. Programs need to be developed to reduce life cycle costs through improvements in durability or standardization of vehicles and support equipment.

5. STUDY FINDINGS AND POTENTIAL FEDERAL ACTIONS

A number of principal findings, resulting from the assessment of urban road transit for the 1980s, are highlighted below. These are followed by a list of all the study findings together with potential Federal actions. A comparative overview of the four scenarios is given in Table 5-1.

1. Assessments of the vehicle manufacturing industry indicate that a perceived market of 5000-6000 vehicles per year for at least 5 years is sufficient to either attract new manufacturers or initiate additional production shifts within existing companies. To ensure such a perception it is necessary to guarantee this level and duration of orders through adequate and multi-year appropriations for vehicle purchases or through direct guarantees to manufacturers that a minimum order will be placed each year. To further encourage competition in the road transit vehicle market in the near term, alternative vehicle sources, specifically the high capacity vehicle industry and the refurbishment industry, should receive proportionally more attention.

2. Large operating deficits associated with the fleet expansions that may be required in this decade will, more than any other factor, constrain service expansion and innovation. Various means of Federal support, such as increased operating subsidy, productivity incentives, training assistance, and research, should be deployed to alleviate this problem.

3. The issues of improved accessibility for mobility handicapped passengers and improved access/egress for general public should be recognized as distinct and severable. Furthermore, the necessity of lowering the vehicle floor height beyond the twenty-four inch height presently attainable is not evident for either issue in light of available alternatives.

The following more detailed list of study findings and Federal actions has been organized into three categories:

1) System Analyses, Assessments and Deployment
2) Vehicles, Subsystems, Facilities, and Wayside Technology
3) Operational Technology

TABLE 5-1. COMPARATIVE SCENARIO OVERVIEW

Scenarios	Average Annual New Vehicle Reqmts.	Projected 1990 Fleet Size	Average Annual ADB Reqmt.	Production Capacity	Subsystem or Supplier Constraints	Bus Snare or Work Trips in 1990
I	2,900 to 4,200	42,000 to 54,000	2,000	Excess capacity. Only 1 shift from 1 manuf. req'd.	none	10%
II	5,800	70,000	4,100	Adequate no addt'l. shifts req'd.	none	
III	7,600	88,000	5,850	One addt'l. shift req'd. Small probability of a 3rd manuf.	none	
IV	10,600 to 15,100	115,000 to 160,000	7,725 to 11,700	A third manuf. is very likely	Potential problems (need to be examined in detail)	30%

Current Situation: 52,500 fleet size
Backlog at start of 1980: 3800 ADBs
GM on one shift: 8 units per day
GFC on two partial shifts: 8 units per day

5.1 SYSTEM ANALYSES, ASSESSMENTS AND DEPLOYMENT

Options in this area address programmatic analyses that are prerequisite to major system, subsystem and technology development. This category encompasses assessments of road transit products, research payoffs and associated industries and existing technology.

Brief Statement of Findings	Brief Statement of Potential Federal Action
a. A major increase in operating deficit is imminent. Operating deficits are the most significant constraint to major bus service expansions and innovative service	Increase available Federal assistance for operating subsidy; identify operational improvements, equipment, techniques to lower O&M costs; encourage local governments to raise fares commensurate with inflation and improve service; increase productivity by promoting planning and coordination of human resource development for road transit.
b. Competitive structure of standard coach supply continues to deteriorate and capital costs continue to escalate Stable (5 years or more) order rates of 5000-6000 vehicles per year appears necessary to encourage third manufacturer or an additional shift.	Guarantee level of demand and duration demand through adequate level of funding for bus purchases. Assess multi-year procurement policy and procedures to permit smoother yearly order rates. Assess recent APTA procurement policy statement.
c. Need to recognize and address new markets in suburban work trips.	Closer examination of the characteristics of suburban work trips and the attendant fleet mix requirements.
d. Any accommodation of expanded transit and increased ridership demands will likely take place within relatively unchanged institutional settings. Policy, planning, programming, funding, regulatory, and operating responsibilities and authorities will continue to be fragmented.	Develop better understanding of local institutional settings to guide Federal policy and financial assistance and deployment of research. Identify mechanisms to aggregate transit responsibilities (such as brokerage concepts)
e. A great deal of confusion as to what constitutes an "acceptable bus" and present vehicle procurement do not properly compensate superior products.	Reexamine the equity and timeliness of price off-sets; establish life cycle costing in bid selection; promote uniform procedure for inspection.

Brief Statement of Findings	Brief Statement of Potential Federal Actions
f. European operations deploy a greater number of buses per capita than U.S. transit operations, as well as a larger proportion of higher capacity vehicles. Current European bus systems may represent the scale of operations that will be obtained in the U.S.	Initiate research to assess selected European operations to identify equipment, techniques, and procedures to improve operational efficiency in U.S. operations.

5.2 VEHICLES, SUBSYSTEMS, FACILITIES AND WAYSIDE TECHNOLOGY

Options in this area address research to improve vehicles or components in an attempt to reduce vehicle life cycle costs, and improve performance. In addition, this category includes efficiency and performance improvements for road transit facilities and wayside equipment and structures, as well as the development of information, guidelines or technology to permit more effective use of capital.

Brief Statement of Findings	Brief Statement of Potential Federal Actions
a. There are numerous technical problems associated with the ADB. Most notable are poor brake life, poor fuel economy, excessive tire wear, subsystem unreliability.	Take the leadership initiative and together with equipment manufacturer and appropriate technology committee coordinate and monitor problem resolutions and hardware improvements.
b. Noise standards may be difficult to meet.	Assess the technical difficulty and identify methods and costs to comply with standards.
c. It is unlikely that the diesel engine will be replaced as the power plant in the next decade and meeting emission standards will conflict with performance goals.	Develop more information to quantify this finding. Seek technology and information transfer from related work on propulsion systems. Continue to assess diesel pollutant issue in conjunction with appropriate agencies/groups.
d. Vehicle refurbishment most likely will become more important.	Re-examine "Interim Guidelines"; refurbishment certification need. Examine bus rebuilding industry as one of the important sources of supply in the road transit system.
e. Absence of sufficient empirical data together with increased emphasis on alternatives create serious doubt on need of lowering floor height beyond the current 24-inch kneeled floor.	Continue to evaluate handicapped and elderly design requirements and mobility options; assess other benefits of low floor buses.
f. Wheelchair lift reliability appears to be a problem.	Establish reliability and cost data on lifts. Encourage manufacturers to continue improving system design and incorporating consumer preferences. Assess result of ongoing test.

Brief Statement of Findings	Brief Statement of Potential Federal Actions
g. Some improvements appear possible within the 3-5 year time period with government support.	Perform research in selected component areas such as low profile tires, more reliable electrical systems, better cooling and brake systems, vehicle retarder systems, air conditioning cut-off during acceleration and constant speed accessory drives.
h. Continuous variable transmissions and other advanced transmissions, which hold the greatest hope for improving driveline efficiency, could be available for road transit during the next decade with significant research and development support.	Define state-of-the-art in transmissions and drivelines; quantify improvements; identify and perform research where warranted to expediate deployment in road transit application.
i. There has been a general weight increase in transit coaches of approximately 5000 pounds since the 1950s, due primarily to deployment of air conditioning and larger engines.	Determine reasonable boundaries for weight reductions; identify and quantify (possibly through experiments) impacts on life cycle costs associated with reducing weight.
j. Consideration to the use of petroleum independent power plant for the next generation transit vehicles.	Not sure how to formulate this.

5.3 OPERATIONAL TECHNOLOGY

Options in this area have as their primary objective the improvement of road transit operations in response to the changing nature of transit demand. Included in this category are items that could potentially improve the reliability, performance, productivity, or efficiency of overall vehicle transit operations. Emphasis is on controlling or reducing operating management and maintenance expenses associated with these systems as well as providing the type of service demanded by transit patrons.

Brief Statement of Findings	Brief Statement of Potential Federal Action
a. Need to encourage improved productivity in all areas of transit operations, maintenance and management.	Encourage use of high capacity vehicles, where justified; institute productivity measures as incentive for supplemental funding; consider providing training program for innovative bus maintenance utilizing improved procedures and equipment; assess usefulness of funding all or greater portions of management training programs. Continue to assess and encourage appropriate fleet mix for demand levels and market types, i.e., identify methods to obtain better utilization (rides per revenue mile).
b. Some fuel efficiency improvements appear possible through weight reduction and improved engines.	Perform research and evaluations of city coaches under various weight reduction situations; perform engine improvement research; interface with DOE projects.
c. Major improvements in performance and fuel economy only possible through completely new vehicle.	Continuous assessment of foreign technology related industry improvements (materials, propulsion, etc.). Currently no need to initiate new vehicle development program.
d. Service records or inventory or operational parameters must be more closely tracked to permit identification of improvements in life cycle costs. Presently no data exist with which to make any findings concerning LCC.	Continue the present UMTA program establishing maintenance and operational data collection and analysis systems for transit properties.

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APPENDIX A. STATE AND LOCAL ACTIONS AND CONSTRAINTS

While the Federal Government provides critical financial support for urban public transportation services, and its policies and regulations have a significant impact, actual service delivery is primarily a product of state and local decision-making and activity. Transit service planning, programming, implementation and operation are non-Federal functions and reflect the diversity and complexity which characterize urban service delivery systems in general and urban transportation arrangements in particular.

In view of the pre-eminent role played by non-Federal entities in providing urban transportation services, efforts to plan for future urban public transportation must include a realistic appraisal of the willingness and capability of these entities to provide an increased level of transportation service. Four aspects that are considered in this section are:

- funding arrangements,
- regulatory environment,
- institutional settings, and
- organizational and operational aspects.

Two important factors must be borne in mind:

1. Although the four topics are considered separately, they are in fact, interdependent; and
2. The necessity to summarize the information tends to conceal the variety and diversity of state and local issues.

A.1 FUNDING ISSUES

Although federal funding for public transportation has rapidly grown in the last decade, the "local share" (in general, the sum of state and local assistance to operators) continues to be an important element in the planning and operational decisions. The forms, levels and sources of funding, however, continue to be controversial.

A.1.1 Funding Levels

National averages of "local share" conceal a wide range of support at the local level. Table A-1 shows the percentages of operating expenses covered by the local share in 80 urbanized areas. Table A-2 shows the percentage of operating expenses covered by Federal (Section 5) funds in the same urbanized area. It is apparent that Federal operating support becomes more important as the size of the urban area decreases.

The local support provided for operating costs had fallen to 70 percent by 1977, and this trend continues.

A.1.2 Funding Sources

An informal survey of 60 transit systems conducted by the American Public Transit Association (APTA) in 1979 identified a number of commonly used mechanisms for funding the capital requirements and operating costs for public transportation. The type of assistance and a list of sources are given in Tables A-3 and A-4 respectively.

A.2 REGULATORY ENVIRONMENT

Local transit service delivery typically takes place within complicated regulatory frameworks made up of the regulatory policies and activities of various levels of government. Regulation of urban transit service may involve routes, service quality, fares, transit financing, labor relations, transit planning, programming, and transit related effects, such as environment and land use.

Regulatory difficulties encountered by transit operators are typically attributed to fragmented responsibility:

> The most common urban transportation regulatory problems are the fragmentation of responsibility for regulating the various kinds of transportation and the separation of regulation from planning and finance. States regulate private bus operations, regional public transit agencies generally regulate themselves, local jurisdictions regulate parking and taxis, and regulation of vanpools usually is ill-defined. Furthermore, regulation, service planning and finance are usually the responsibility of different agencies, making integrated public policy dicisions on fares, levels of service, modes and levels of public support difficult to achieve.

TABLE A-1. LOCAL SHARE OF TRANSIT OPERATING EXPENSE AS A PERCENT OF TOTAL OPERATING EXPENSES IN 80 URBANIZED AREAS (1976)

Urbanized Area Population	Percentage	Range
Over 1,000,000	36	14 - 70
500,000 - 1,000,000	32	10 - 58
200,000 - 500,000	29	19 - 47
50,000 - 200,000	30	15 - 53
AVERAGE	35	10 - 70

TABLE A-2. SECTION 5 OPERATING ASSISTANCE AS A PERCENT OF OPERATING EXPENSES IN 80 URBANIZED AREAS

Urbanized Area Population	Percentage	Range
Over 1,000,000	9	3 - 25
500,000 - 1,000,000	17	5 - 31
200,000 - 500,000	20	12 - 39
500,000 - 200,000	24	15 - 53

TABLE A-3. INDIRECT ASSISTANCE TO LOCAL TRANSIT OPERATORS

TYPE OF ASSISTANCE	PARTICIPATING STATES
Exempt from Local Property Taxes	Nearly All
Exempt from Motor Fuel Taxes	Nearly All
Authority to Sell Tax Exempt Bonds	About Half
Exempt from State Income Taxes	About Half
Exempt from Local Income Taxes	Less than Half
Exempt from Otor Vehicle Registration Fees	Most
Fares Exempt from Sales and Use Tax	Most
Exempt from Special Assessments	About Half
Exempt from Excise Taxes	About Half
Lease of Operating Equipment at Less Than Cost	Five
Exemption from Franchise-License Fee	About Half

TABLE A-4. SOURCES OF REVENUE FOR STATE FINANCIAL ASSISTANCE TO TRANSIT

State	Source
Alaska	Appropriations from general revenues
California	State sales tax
Connecticut	State transportation fund
Delaware	Appropriations from general revenue
Florida	State transportation fund
Georgia	Appropriations from general revenue
Hawaii	Appropriations from general revenues
Illinois	Appropriations from general revenues, state sales tax, registration fees
Kentucky	Appropriations from general revenues
Maryland	State transportation fund
Massachusetts	Appropriations from general revenues, cigarette tax
Michigan	Appropriations from general revenues, state transportation fund
Minesota	Appropriations from general revenues
Nebraska	Appropriations from general revenues
Nevada	State transportation fund
New Jersey	Appropriations from general revenues
New York	Appropriations from general revenues
Ohio	Appropriations from general revenues
Pennsylvania	Appropriations from general revenues, state lottery
Rhode Island	Appropriations from general revenues
Tennessee	Appropriations from general revenues
Virginia	Appropriations from general revenues, state transportation fund
Washington	Registration fees
Wisconsin	Appropriations from general revenues

Regulatory decisions have frequently been the responsibility of city and state agencies which perform no other functions in urban transportation. As a result, regulation has not been coordinated with public policy on planning, finance and operation. Typically, no single agency has had the authority to decide on a level of service and choose a method to supply that service effectively and at least cost to the public.

A.2.1 Vehicles

Virtually all states regulate the sizes of road transit vehicles. The standard maximum dimensions for buses are 96 inches width and 40 foot length. Some deviations from the standard are shown in Table A-5. It should be noted that vehicles operating on Interstate highways constructed with federal funds are limited to 96 inches width. Standard bus widths are 96 inches and 102 inches. Twenty states still limit buses to 96 inch widths.

Standard weight per axle is 20,000 pounds. Some states impose an 18,000 pound limit. Both the Advanced Design Buses currently in production exceed the 20,000 pound axle limit when operating fully loaded.

In addition, there are many variations in vehicle regulations in connection with factors such as door interlocks, marker lights, seat belts for drivers, etc.

A.2.2 Supporting Equipment and Facilities

Land use regulations frequently inhibit the location of bus garages and supporting facilities. In addition, local building and electrical codes vary widely. These inhibit the use of standard designs.

A.2.3 Service Standards

For many years service standards were restricted to limiting maximum passenger loading. However, since the intervention of state and local governments in the funding process, attempts are being made to regulate the quantity and quality of transit services being provided to the public. Factors often controlled include route densities, headways, and bus loadings. Occasionally, state operating support is made contingent on meeting specific service standards.

TABLE A-5. BUS SIZE LIMITS

	Width (inches)	Length (feet)
Standard	96	40
California	104	40
Connecticutt	102	55
Hawaii	108	40
Maine	102	45

A.3 INSTITUTIONAL SETTINGS

Local transit service providers operate in highly complex institutional settings. Multiple levels of government participate in the overall service delivery process. Frequently, many agencies within a single level of government are involved (planning, transportation, and budget for example). Local transit service also involves multiple jurisdictions and overlapping government structures. As one report states:

> 1. The transportation needs of the typical metropolitan area are served by a varying combination of general purpose governments, special districts, and private providers. Diffusion of responsibility and jurisdictional fragmentation are the chief characteristics of metropolitan transportation service delivery patterns. The average metropolitan area has 11 "urbanized" municipalities, three counties, 38 special districts and four transportation districts serving a population of approximately 655,700.
>
> 2. Several possible service providers, the municipality, the county, the state, independent and dependent special districts, and the private sector, are involved in metropolitan transportation. The ways these units combine to provide services depend upon:
>
>   - o population size,
>   - o the number of modes of transportation,
>   - o location in different parts of the nation, and
>   - o the state and local governmental traditions applicable to the individual urban area.

While, to some degree, federal support of areawide transportation planning and review bodies (MPOs) has provided an internal mechanism for mitigating the effects of the complexity and fragmentation noted, evidence suggests that the tensions and conflicts arising from the nature of urban institutional structures continue to affect transit planning and programming process and outcomes and to dilute the impact of Federal initiatives and incentives. One study of ten large existing systems concludes:

> In spite of these efforts to create a structure for effective, coordinated regional planning, the context for transit decision-making in all the metropolitan areas examined falls short. Although on paper the organizational structure of the decision-making forum in each metropolitan area is well defined, metropolitan experience shows that in practice transit responsibilities are fragmented among a great number and variety of local, regional, and state agencies of government. The separate responsibilities of each of the levels of government are not clearly enough defined for any one agency to have decisive authority either for setting policy or for obtaining financing and other commitments necessary to implement a plan.

Although some observers suggest that state and local trends toward metropolitan regionalism and development of balanced multimoded transportation networks will result in institutional and organizational changes which will facilitate responsive and comprehensive transit decision-making and operation, such changes cannot be assumed in the short-run (i.e., by the 1990s). Accommodation of expanded transit provision and increased ridership demands will likely take place within relatively unchanged institutional settings. Policy, planning, programming, funding, regulatory and operating responsibilities and authorities will continue to be fragmented.

A.4 ORGANIZATIONAL AND OPERATIONAL RESOURCES

While there is, of course, no single organizational or operational pattern for local transit operations, it is important to recognize that local transit organizations and operational patterns have evolved over a number of years in response to particular local requirements, characteristics, and priorities. Existing transit organizations have established institutional relationships and operational routines. These relationships and routines are often based on prevailing, conventional assumptions regarding the types of transit service demanded and supplied and have significant implications for efforts to bring about short term changes in transit service policies and levels. Inertia surrounding existing methods has been seen as a barrier to both service innovation and increased efficiency of traditional services. Organizational and operational issues are also regarded as barriers to enhanced levels of coordination and cooperation in urbanized areas; development of expanded ridership and ridership capacity throughout urbanized areas, however, would require higher levels of coordination than are currently observed or, perhaps, currently achievable.

Both direct service providers and supporting organizations may experience difficulties in providing adequate personnel and expertise to initiate and sustain new and/or different levels and types of service--particularly in the short-run. Expanded fleets would exacerbate existing shortages of maintenance personnel in some areas. Expanding bus networks into currently unserved areas would require expansion of both planning and management levels. Transit management shortages have already been noted in the transit industry. UMTA officials, for example, recently expressed concern about apparent shortages in trained management personnel. Such concern is supported by research which indicates that relatively little formal organization and planning concerning the development and utilization of managerial resources exist within the industry and that during the next decade the majority of professionally trained industry leaders will retire without an adequate supply of replacement personnel.

While these kinds of organizational and operational capacity issues do not lend themselves to quantitative appraisal and projection and have not been the subject of extensive research, the experience provided by attempts to rapidly expand service provision levels in other Federal program areas (e.g., housing and social services) suggests that these issues should not be discounted. HUD, for example, has undertaken a considerable level of effort to develop methods of increasing local planning and management capacities.

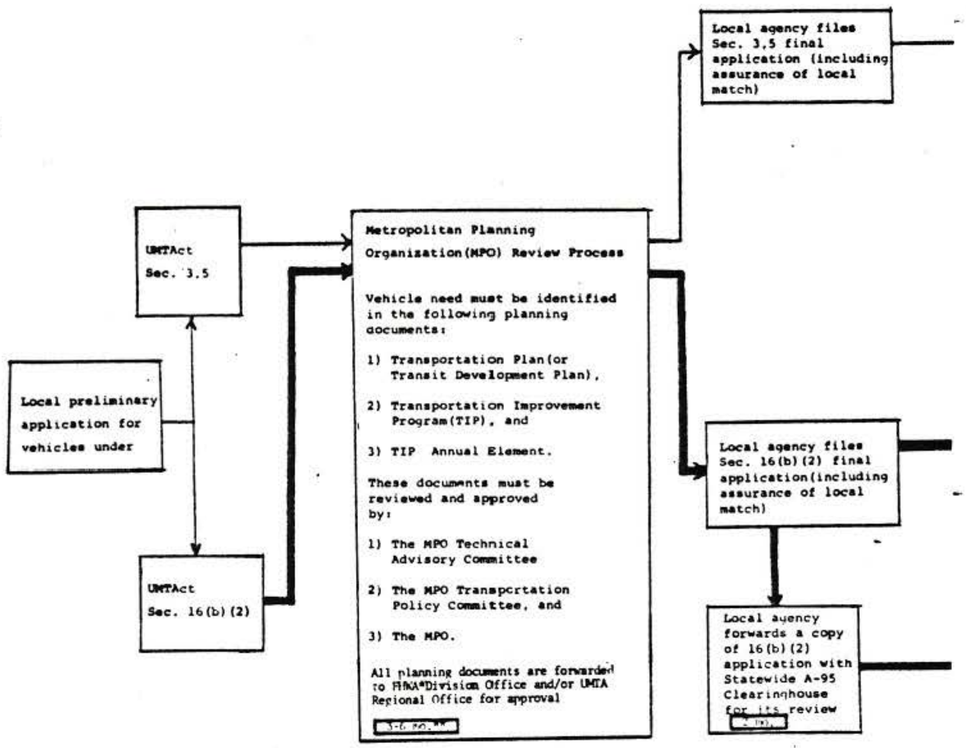
APPENDIX B. VEHICLE PROCUREMENT FLOW CHART

Figures B-1 and B-2 are representative flow charts depicting the process of procuring road transit vehicles. Certain portions of this process are highlighted in the following paragraphs while additional, more detailed information on the UMTA grant application itself is contained in "Application Instructions for Capital Grant Projects," UMTA Document # 1000.2, Chg. 3, 5-10-74.

Virtually all vehicle procurements for public road transit have their beginning in some planning document. Typically, in metropolitan areas these plans are called either Transit Development Plans or Transportation Improvement Programs. The plans are created or updated generally every five years by metropolitan planning organizations (MPOs). If, for some reason, such as an unplanned increase in ridership, more vehicles or facilities are needed than are allocated in the existing plan, the planning document must be revised and subsequently approved by various sections of the MPO. This could take up to six months or more since these MPOs and their subcommittees meet only a few times a year.

When the appropriate UMTA regional office receives the grant application, it forwards copies to the U.S. Department of Labor (DOL), whose responsibility it is to ensure compliance of the labor protection provisions of Section 13(c) of the UMT Act. Such certification by DOL is an essential prerequisite of the legal review of the grant application. Such certification time varies widely depending on the type and content of the grant application.

The time frame from preliminary application to the initiation of the vehicle bid process can be anywhere from 12 to 18 months or longer.

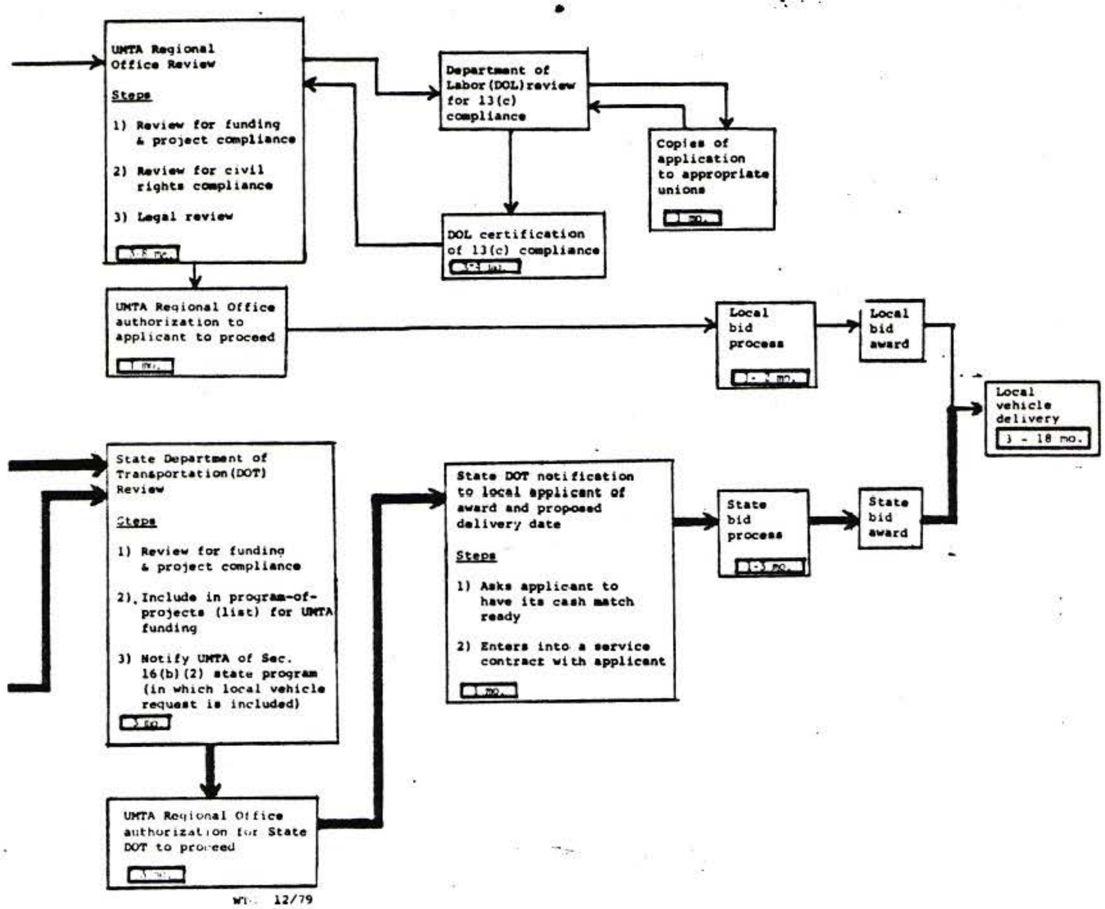


* FHWA = Federal Highway Administration

** This represents the approximate(minimum and maximum when two numbers are given) time frame in months for completing a step.

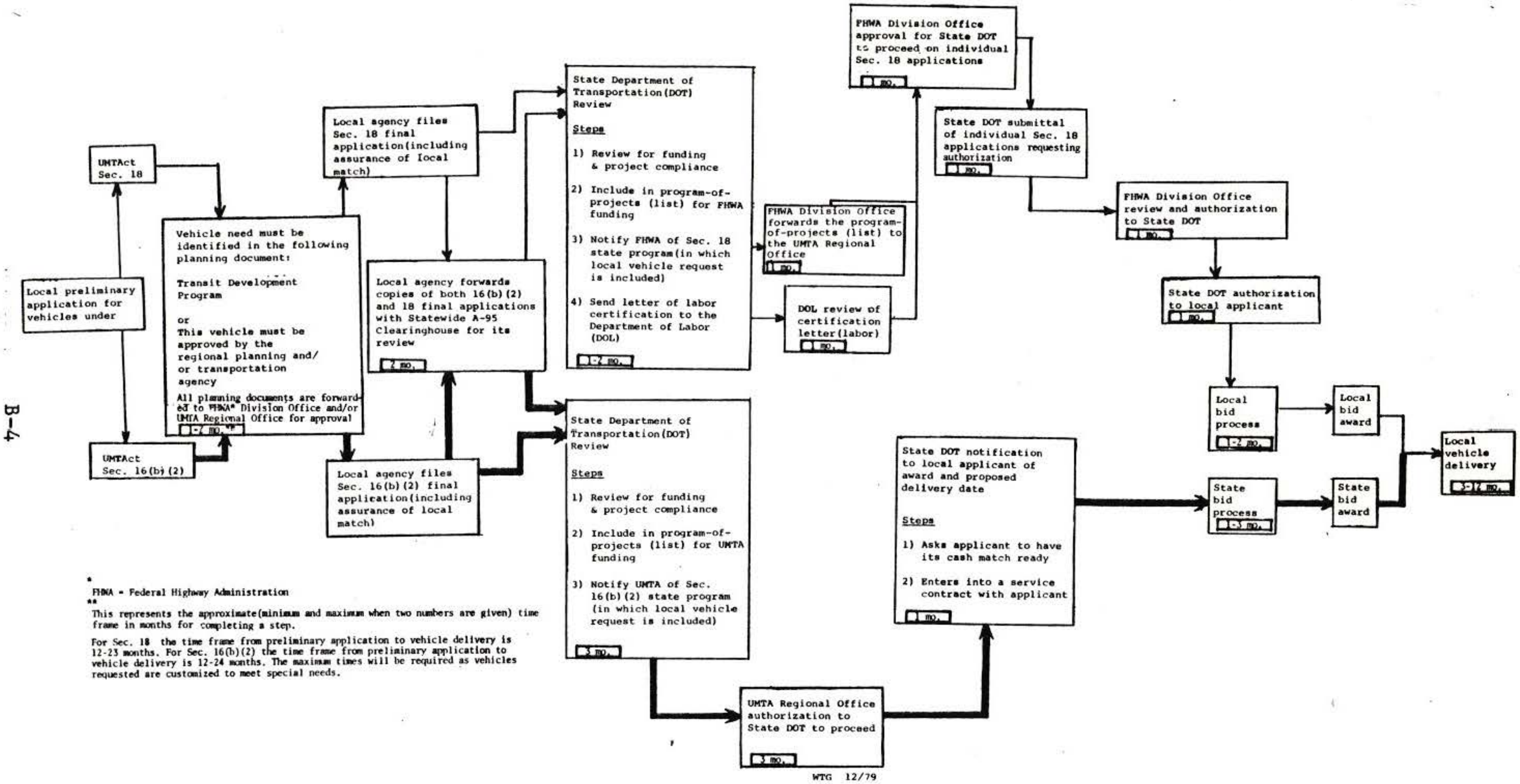
For Sec. 3 and 5 the time frame from preliminary application to vehicle delivery is 11-29 months, for Sec. 16(b)(2) the time frame from preliminary application to vehicle delivery is 14-28 months. The maximum times will be required as vehicles requested are customized to meet special needs.

FIGURE B-1. VEHICLE PROCUREMENT FLOW CHART
Urbanized Area Grant Programs (Sections 3, 5, and 16(b) (2))



85

FIGURE B-1 (Cont.)



* FHWA - Federal Highway Administration

** This represents the approximate (minimum and maximum when two numbers are given) time frame in months for completing a step.

For Sec. 18 the time frame from preliminary application to vehicle delivery is 12-23 months. For Sec. 16(b)(2) the time frame from preliminary application to vehicle delivery is 12-24 months. The maximum times will be required as vehicles requested are customized to meet special needs.

FIGURE B-2. VEHICLE PROCUREMENT FLOW CHART
Non-urbanized Area Grant Programs (Sections 16(b) (2) and 18)

APPENDIX C. FOREIGN BUS PRODUCTION AND OPERATIONS

C.1 FOREIGN BUS PRODUCTION

Bus production in many European countries exceeds U.S. production. In 1978 Germany produced over 14,000 buses, and the United Kingdom produced 23,000. Tables C-1 and C-2 present data for several European nations. The data is in complete, and no attempt has been made at this time to assess European production capacity.

European bus production as a percent of truck sales ranges from a low of 1 percent in France to over 10 percent in Sweden. In 1978, registration of new buses relative to that of trucks ranged from 3 percent in France to 6 percent in Sweden while new bus registrations in the U.S. represented 0.5 percent of truck sales. European new bus registration accounted for a larger portion of the combined truck and bus registrations, but bus registrations are still a relatively insignificant portion of total registrations and total vehicle production.

C.2 FOREIGN BUS OPERATIONS

Statistics on bus operations in representative world cities are given in Table C-3. Comparative statistical values for selected U.S. cities are provided in Table C-4. It is seen from these two tables that the operating fleets per million population in many foreign countries are up to three times of those operated in the U.S. cities. Clearly, distinctions in geography, environment, social and economic factors exist between U.S. and foreign cities. However, fleet sizes per capita and annual bus rides per capita in cities outside the U.S. indicate that many foreign transit systems are apparently operating relatively large fleets and effectively servicing large demands. With emerging ridership demands presently being experienced in this country, it appears reasonable to initiate investigations in foreign road transit services, management techniques, and maintenance procedures.

As a reasonable check of the scenarios developed in this report, three additional tables are included. Table C-5 gives an estimate of the population growth by 1990 for 25 urbanized areas in the U.S. Table C-6 shows the number of vehicles per million population and the fleet utilization factor

TABLE C-1. OTHER VEHICLE PRODUCTIONS (1978 - MVMA)
(Company Data Not Comparable, Listed Only When Available)

	Cars	Trucks	Buses	All Vehicle Total
France				
Total Country	3,111,380	392,867	3,683	3,507,9
Company - Saviem		25,848	2,379	30,733
Germany				
Total Country	3,625,501	265,812	14,585	4,186,36
Company - Daimler Benz	382,622	138,346	8,210	560,73
Italy				
Total Country	1,608,599	142,208	5,308	1,656,113
Company - Fiat	1,104,076	126,905	4,851	1,235,78
Fiat OM		12,305	457	12,662
Sweden				
Total Country	254,256	46,534	4,744	305,534
Company - Volvo	181,740	27,530	9,414	211,684
Saab/Suma	72,516	19,004	2,330	93,850
UK				
Total Country	1,222,949	361,496	23,042	1,607,4
Belgium				
Total Country	954,262	32,603	1,427	1,093,07

TABLE C-1. (CONTINUED)

	Cars	Trucks	Buses	All Vehicle Total
Netherlands				
Total Country	66,262	8,621	621[(1)]	85,200
Company - Boyd			85	
Daf			493	
Leland			43	
Spain				
Total Country	986,116	85,291	2,873	1,143,83

Note: Company volumes may exceed country totals due to vehicles manufactured by parent company in another country.

TABLE C-2. EUROPEAN BUS PRODUCTION AND REGISTRATIONS IN RELATION TO OTHER VEHICLES

Production	% to Trucks	% of Total Units Produce
France	.90	.11
W. Germany	7.10	.52
Italy	4.44	.32
Sweden	10.14	1.27
Belgium	9.79	1.95
Registration (New)		
France	2.75	.38
W. Germany	5.17	.23
Italy	5.33	.37
Sweden	5.92	.32
Registration (Total)		
France	2.25	.28
W. Germany	5.86	.30
Italy	3.88	.27
Sweden	8.00	.43
Belgium	8.37	.65
Denmark	2.52	.40
Finland	6.33	.75
Norway	6.64	.79
Sales		
Spain	3.25	

TABLE C-3. BUS STATISTICS FOR WORLD CITIES

METRO. AREA	FIXED GUIDEWAY STATUS[1]	METRO. POP. ($X10^3$)	BUSES PER MILLION POP[2]	RTE.-MILES PER MILLION POP	VEH.-MILES PER CAPITA	VEH.-MILES PER VEH.	ANNUAL BUS RIDES PER CAPITA	RIDES PER VEH.-MILES
Barcelona	X	2,800	330 (346)	89	10.0	30,200	91	9.1
Berlin	X	2,000	761 (1,038)	325	25.0	32,830	262	10.5
Birmingham		2,700	990 (1,448)	465	28.2	28,513	198	7.0
Bordeaux		600	758	561	16.4	21,567	105	6.4
Copenhagen		1,758	594	1,270	28.3	47,381	118	4.2
Edinburgh		454	1,346 (1,883)	314	40.8	30,278	322	7.9
Glasgow	X	1,915	555 (831)	285	16.2	29,222	104	6.4
London	X	7,028	988 (1,391)	579	16.2	16,376	202	12.5
Manchester		2,800	1,081 (1,513)	429	19.6	18,176	165	8.4
Montreal	X	2,919	677	198	17.1	25,317	104	6.1
Newcastle-upon-Tyne	C	1,200	518 (700)	500	16.5	31,752	108	6.5
Paris	X	8,550	454	153	9.7	21,402	83	8.6

[1]Fixed Guideway Status:
X = exists
C = constructing

[2]Numbers in parentheses are equivalent standard buses/capita, where 1 double deck bus equals 1.5 standard bus.
Source: UITP Handbook of Urban Transport, 1979.

TABLE C-4. BUS STATISTICS FOR THE LARGE URBANIZED AREAS

Urbanized Area	Fixed Guideway Status[1]	Urbanized Area Pop. ($X10^3$)	Buses Per Million Pop.	Rte.-Miles Per Capita	Rev.-Miles Per Capita	Rev.-Miles Per Veh.	Annual Bus Rides Per Capita	Rides Per Rev.-Mile
Atlanta	X/C	1,521	515	4,919	17.4	33,875	56	3.2
Baltimore	C	1,720	569	458	15.5	27,219	62	4.0
Buffalo	C	1,121	422	1,682	9.1	21,592	39	4.3
Chicago-N.W. Indiana	X	7,464	409	294	11.1	27,070	90	8.1
Cincinnati		1,198	482	1,960	12.6	26,148	40	3.2
Dallas		1,686	270	323	7.7	28,454	20	2.6
Denver		1,374	379	2,940	14.7	38,866	31	2.1
Detroit		4,348	280	732	8.2	29,179	19	2.3
Los Angeles-Long Beach		10,132	327	170	12.0	36,788	39	3.3
Miami	C	1,652	368	1,659	11.4	30,998	41	3.6
Milwaukee		1,358	460	852	12.6	27,362	49	3.9
New Orleans	X	1,162	448	667	13.2	29,405	78	5.9
New York-New Jersey	X	17,412	545	1,051	13.7	25,135	54	3.9
Philadelphia	X	4,716	330	2,286	10.0	30,383	47	4.7
Pittsburgh	X	1,907	575	2,271	17.7	30,826	54	3.1
Portland		926	559	1,941	21.9	39,205	43	2.0
San Diego		1,652	302	808	12.1	39,866	27	2.1
Washington, DC	X/C	3,090	625	5,050	13.8	22,126	42	3.0

[1]Fixed Guideway Status:
X = exists
C = constructing

Sources: Statistics for buses, route-miles, and revenue-miles are from Office of Transit Assistance Fleet Inventory as compiled by Booz-Allen.
Statistics for bus ridership and derived from APTA Monthly Ridership (unlinked rides) Reports.

TABLE C-5. URBANIZED AREA POPULATION
(thousands)

	1970	1978 estimate	1990 estimate
New York - New Jersey	16,206	17,412	19,251
Los Angeles - Long Beach	8,351	10,132	12,730
Chicago - N.W. Indiana	6,715	7,464	8,431
Philadelphia	4,021	4,716	5,318
Detroit	3,971	4,348	4,867
San Francisco - Oakland	2,988	3,597	4,308
Boston	2,653	3,137	3,420
Washington, DC	2,481	3,090	3,801
Cleveland	1,960	2,167	2,364
St. Louis	1,883	2,069	2,228
Pittsburgh	1,846	1,907	1,885
Minneapolis - St. Paul	1,704	1,975	2,298
Houston	1,678	2,265	2,846
Baltimore	1,580	1,720	2,091
Dallas	1,339	1,686	2,091
Milwaukee	1,252	1,358	1,555
Seattle	1,238	1,588	1,940
Miami	1,220	1,652	2,267
San Diego	1,198	1,531	2,089
Atlanta	1,173	1,521	1,964
Cincinnati	1,111	1,198	1,313
Buffalo	1,087	1,121	1,226
Denver	1,047	1,374	1,685
New Orleans	962	1,162	1,337
Portland	825	926	1,134
Total for 25 Urbanized Areas	73,387	79,595	94,439
Total for all Urbanized Areas	118,447	137,899	163,182

Sources: 1970 Urbanized Area populations are from County and City Data Book, U.S. Department of Commerce, 1972.

1978 and 1990 urbanized area estimates are based on SMSA projections developed by U.S. Commission on Population Growth and the American Future in Population Distribution and Policy, Sara Mills Mazie, editor, Vol. V of Commission reports, 1972. The urbanized area estimate assumes the same population proportion of the SMSA for 1978 and 1990 as was observed in 1970.

TABLE C-6. BUSES VS. URBANIZED AREA POPULATION: 1978

Urbanized Area[1]	Buses Per 1 Million Population: Total Fleet	Buses Per 1 Million Population: Peak Fleet	Fleet Utilization	Fixed Guideway Status[2]
Washington, DC	625	591	.946	X/C
Pittsburgh	575	414	.720	X
Baltimore	569	501	.881	C
St. Louis	567	394	.695	
Portland	559	481	.861	P
Seattle	557	380	.682	
New York-New Jersey	545	414	.760	X
Atlanta	515	481	.934	X/C
San Francisco-Oakland	499	401	.804	X
Minneapolis-St. Paul	497	454	.914	
Cincinnati	482	378	.784	
Milwaukee	460	344	.748	
New Orleans	448	374	.835	X
Cleveland	432	358	.829	X
Buffalo	422	328	.777	C
Chicago-N.W. Indiana	409	371	.907	X
Denver	379	303	.800	
Miami	368	262	.712	C
Philadelphia	330	286	.867	X
Los Angeles-Long Beach	327	244	.746	P
Boston	323	296	.916	X
San Diego	302	238	.788	P
Detroit	280	210	.750	P
Houston	273	165	.604	
Dallas	270	248	.919	
25 Urbanized Area Average	441	357	.810	
All Urbanized Area Average (Est.)	360	290	.810	

[1]These 25 Urbanized Areas account for 35,527 total buses and 28,261 peak buses, or about 70% of all Urbanized Area total buses and peak buses.

[2]Fixed Guideway Status: X=exists
C=in construction
P=planned

Sources: Total fleet is based on 1978 Urbanized Area bus inventory compiled by Booz, Allen & Hamilton, Inc. for Office of Transit Assistance, UMTA. Peak Fleet is based on reported figures in Mass Transit, October 1979 for the same 25 urbanized areas in 1978. Projecting this information into 1990 with the estimated population for these cities, it is estimated in Table C-7 that the total peak fleet required by 1990 will lie between 54,380 and 76,350, a number somewhere between Scenario II and Scenario III.

TABLE C-7. PEAK FLEET REQUIREMENTS BY URBANIZED AREA

	Peak Buses Per 1 Million Population		Peak Fleet Requirements	
Urbanized Area	1978	1990 Estimate Range	1978	1990 Est. Range
New York - New Jersey	414	400-450	7,210	7,700-8,660
Los Angeles - Long Beach	244	400-550	2,475	5,090-7,000
Chicago - N.W. Indiana	371	400-450	2,770	3,370-3,790
Philadelphia	286	350-400	1,350	1,860-2,130
Detroit	210	400-550	910	1,950-2,680
San Francisco - Oakland	401	500-550	1,440	2,150-2,370
Boston	296	350-400	930	1,200-1,370
Washington, DC	591	500-550	1,825	1,900-2,090
Cleveland	358	400-550	775	950-1,300
St. Louis	394	450-600	815	1,000-1,340
Pittsburgh	414	500-550	790	940-1,040
Minneapolis - St. Paul	454	550-600	900	1,260-1,380
Houston	165	400-600	370	1,140-1,710
Baltimore	501	550-600	860	1,150-1,250
Dallas	248	400-600	410	840-1,250
Milwaukee	344	500-600	470	780- 930
Seattle	380	500-600	600	970-1,160
Miami	262	400-450	430	910-1,020
San Diego	238	400-500	365	840-1,040
Atlanta	481	500-550	730	980-1,080
Cincinnati	378	450-600	450	590- 790
Buffalo	328	400-500	370	490- 610
Denver	303	400-600	415	670-1,010
New Orleans	374	400-500	435	530- 670
Portland	481	550-600	445	620- 680
25 Urbanized Areas Total			28,540	39,880-48,350
Other Urbanized Areas	225	350-400	13,000	24,500-28,000
Total All Urbanized Areas			41,540	54,380-76,350

APPENDIX D. BACKGROUND ON VEHICLE AND SUBSYSTEM SUPPLY INDUSTRY

D.1 BACKGROUND ON VEHICLE MANUFACTURERS

Table D-1 lists the major manufacturers of urban transit vehicles. The vehicle manufacturers and their subsystem suppliers comprise the road transit industry as defined in this study.

D.1.1 Standard Transit Bus

The two U.S. producers of standard size transit buses are General Motors and Grumman Flxible. GM began producing its "old look" transit bus in 1939 and offered this bus until 1959 when it announced its "new look" design. Flxible began producing buses in 1924. Numerous models have been offered by Flxible including a "new look" design which was produced from 1973-78. Historically, GM and Flxible have been the principal two U.S. manufacturers of standard size buses. In addition, each company has previously offered 30-foot versions of its standard bus. Because of alleged monopolistic practices, in 1965, GM and the Justice Department entered into a consent decree requiring GM to sell parts and components to competitors. At that time GM had 85 percent of the market and Flxible had the remainder. By 1970, when Rohr Industries bought Flxible, GM had 55 percent of the market and Flxible 45 percent.

In 1971, AM General announced it was entering the transit bus business, and in 1974, delivered its first buses. By 1977, AM General had 34 percent of the market, but in May 1978, it announced it was dropping out of the bus market, citing confusion over Federal requirements as the reason. Both GM and Flxible introduced their advanced design buses (ADBs) in 1978. In the same year Grumman bought Flxible from Rohr. The ADBs replaced the "new look" designs. As of 1978, transit properties who want to purchase "new look" buses must buy them from either Flyer Industries, a Canadian firm, or GMC of Canada.

TABLE D-1. URBAN TRANSIT VEHICLES

		MANUFACTURERS	VEHICLE SIZE
High Capacity		AM General (MAN)	Articulated 54', 65 pass.
Over 40 feet		Crown Coach (Ikarus)	55' or 60', 71 pass. (arti.
		Gillig-Neoplan	double decker
Standard	"New look"	AM General	Trolleybus 40'6"; 46 pass.
35-40 feet	"New look"	GM Canada	35', 45 pass. 40', 53 pass.
	"New look"	Flyer Industries	trolleybus 40'; 51 pass. bus 40', 51 pass.
	ADB	GM	RTS 2 35', 39 or 47 pass. 40', 39 or 47 pass.
	ADB	Grumman Flxible	#870 35', 40 pass. 40', 48 pass.
Small		Greyhound (TMC)	30'8", 32 pass.
28-32 feet		Gillig-Neoplan	30'11", 30-35 pass.
		Flyer Industries	31', 32 pass.
		Blue Bird	30', 31 pass.
		Argosy/Airstream	28', 29 pass.
		Carpenter	29'-39'; 36-56 pass.
		Atlantic Research	24'-28'; 29 pass.

D.1.2 Trolleybus

When AM General withdrew from the transit bus market, they entered the trolley bus market. They were the first U.S. firm to produce trolley buses in over 20 years. U.S. transit properties had been buying trolley buses from Flyer Industries who still produces them.

D.1.3 High Capacity Vehicles

Heavily travelled metropolitan transit routes require higher capacity vehicles such as double decker or articulated buses. AM General, until recently, was offering the MAN bus built in Germany. MAN recently withdrew its license to AM General. Close to 400 articulated buses have been ordered. Crown Coach Corp. is currently marketing the Hungarian Ikarus articulated bus. Several Neoplan double deck coaches have been purchased for use in Los Angeles.

D.1.4 Small Transit Bus

GM ceased production of small transit buses in 1964, and Flxible continued to produce its 30-foot bus until its ADB went into production. In 1978, Transportation Manufacturing Corp., a division of Greyhound, announced production of its 31-foot Citycruiser based on a design originated by Ontario Bus Industrie. In addition, Flyer and Neoplan offer comparable vehicles. A variety of modified recreational vehicles and school bus type vehicles are also available in this size range.

D.1.5 Mini-bus

In contrast to the manufacturing industries for standard, high capacity and small buses, numerous small firms offer vehicles in the under 28-foot size. The rate of entry and exit from this market is so high that it is difficult to keep track of firms that are in the business. Further, purchasers of these vehicles are not limited to public transit operators. Both the large number of manufacturers in this market and the variety of customers, both public and private, make it impossible to perform a complete assessment of manufacturing capacity at this time.

TABLE D-2. MAJOR BUS SUBSYSTEMS

- Propulsion Systems
  - Diesel engines
- Transmissions
- Axle and Gear Assemblies
- Heating/Ventilation/Air Conditioning
- Wheelchair Lifts/Stepwells
- Seats
- Windows and Sashes
- Door, Operators and Controls
- Brakes
- Tires
- Interior and Exterior Lighting
- Batteries
- Driver (Operator's) Console
- Air Operating System
- Hydraulic Operating Systems
- Flooring
- Route Indicators
- Bumpers
- Electrical System

D.2 BACKGROUND ON SUBSYSTEM SUPPLIERS

Vehicle subsystem suppliers are a vital part of the bus manufacturing industry and are important to the rebuilding capacity as well. Major bus subsystems are identified in Table D-2. The subsystem and components supply industry is comprised of an estimated 50 major suppliers and perhaps an equal number of minor suppliers. Typically, they also participate in other markets including automobiles, trucks, trailers, school buses, rail passenger vehicles and industrial products. Frequently, the most serious problems are created by would-be suppliers to the transit bus industry who do not appreciate the heavy duty service requirements of the urban road transit vehicles. Durabilit is a challenge. For example, bus doors may open and close as many as seven million times during the 20-year life of some vehicles.

While procurement policies of vehicle manufacturers normally favor dual sourcing, a trend toward sole source of supply for an increasing number of major transit bus components has recently been developed. The list of components for which one industry source dominates is given in Table D-3.

TABLE D-3. SUBSYSTEM SUPPLIERS

Major Bus Component	Source of Supply
Engine	Detroit Diesel Allison/GMC
Transmission	" " " "
Rear axle and gears	Rockwell International
Passenger seats	American Seating
Driver seat	National Seating
Floor covering	R.C.A. Rubber
Air compressor	Bendix-Westinghouse
Power steering gear	Sheppard
Wiper/washers	Sprague
Alternator	Delco Remy Division/GMC

As shown in Table D-3, Detroit Diesel Allison Division of GMC has been the dominant supplier of transit bus engines. It is important to realize, however, that the bus performance depends largely upon the combined characteristics of the engine-transmission combination and the final drive gear ratio. Detroit Diesel currently supplies two engine models - DDAD 6V71N and DDAD 8V71N - for the standard 35 and 40 foot bus sizes.

The only other major engine manufacturer is Cummins Engine Co. It makes excellent diesel engines for the medium and heavy duty truck and off-highway transportation markets. Cummins' attempt in the past to enter the transit market has been unsuccessful. This was due mostly to the economic decline of the sixties when conditions became virtually impossible for any new engine offering to interest transit operators who were then preoccupied with defensive facilities and equipment strategies. However, both Detroit Diesel and Cummins are now introducing relatively new engine models to compete with the 8V71N:

Detroit Diesel	6V92TA
Cummins Engine Co.	VTB-903.

Another bus subsystem which has received a great deal of attention is the air conditioning. With the recent introduction of Advanced Design Buses incorporating fixed sash windows, the operating reliability of motor bus air conditioning systems has taken on importance, the criticality of which may have been blown out of proportion. Whereas failures of air conditioning on "New Look" buses with openable windows were corrected at the time convenience of the operator maintenance department, comparable failures on ADB buses are considered reasonable cause to take buses out of service.

Transit bus air conditioning systems consist of approximately 14 operating elements. The major elements are:

- Refrigerant compressor
- Refrigerant gas
- Condenser, with fan, drive, and control
- Evaporator, with fan(s), motors, and control
- Expansion valve
- Heat exchanger
- System climate control.

They are, however, completely separable in themselves because of their inter-relationship for control and air distribution purposes with the bus passenger heating subsystem. Hence, in the broader view, bus air conditioning is a sub-subsystem within the heating, ventilating, and A/C subsystem, or climate control subsystem.

The principal suppliers of major air conditioning components are:

- o Refrigerant Compressors - Trane Corp., Delco Remy
- o Evap and condenser coils - Trane Corp., Halstead Industries
- o Controls - Honeywell Corp., Flxible, Vapor Corp.

Additional suppliers who may become a factor in future sales to bus builders are the Carrier Corporation and Thermo King Corp.

In summary, any of the supply firms must meet the aggregate demand of the two remaining U.S. standard transit bus builders plus parallel demands from other markets which usually provide their production bases. Their collective capabilities are of strategic importance to the continued supply of buses in the U.S., as unexpected interruptions in their production of bus components could seriously impact the output of buses.

APPENDIX E. VEHICLE REFURBISHMENT INDUSTRY

E.1 BACKGROUND

The transit coach refurbishment industry has been examined on the basis of extremely limited contacts, and, therefore, it is necessary to make some intuitive judgements of both operator and contractor rebuilders, the two key sources of motor bus rebuild capability.

Various definitions for bus rehabilitation or rebuild exist. These differ primarily in degree of completeness of functional and aesthetic restoration. One bus rebuilder has defined essentially two levels of bus rebuild which are outlined as follows:

Level 1 - REBUILD, COMPLETE

Includes complete body, structural, and component repair and/or replacement of new or rebuilt components as specified, including engine-transmission

Level 1A - REBUILD, COMPLETE WITHOUT ENGINE

Level 2 - REBUILD, PARTIAL (As specified).

This definition might be compatible with some typical transit maintenance and overhaul programs which are delineated below.

	3-4 Years	6-8 Years	12-15 Years	Relative Costs
Overhaul, light	X			$ 5-10K
Overhaul, heavy		X		10-15
Rebuild, partial			X	15-25
Rebuild, complete			X	25-50

Uniform terminology defining partial rebuilds does not exist. Partial rebuilds may or may not include the overhaul of the propulsion and braking system or other components of the total bus system. Partial rebuilds may have the prime purpose of cosmetic refurbishment which includes the interior seating, flooring, and doors, as well as the exterior paint and trim.

A complete bus rebuild could involve all components including body and structural elements. It would typically require stripping the interior shell and portions of the exterior skin to reveal corrosion and need for structural repair. Many properties do not rebuild completely, preferring to terminate the service life of the vehicle rather than to operate beyond some economically practical point based on bus condition. These properties question the economic return of complete rebuilds. Other properties feel the results are worthwhile, and plan for complete rebuild somewhere in the 12 to 15 year range so as to obtain another 5 to 10 years of reasonable service life. What constitutes "reasonable" service life differs among properties. A property may contemplate the assignment of rebuilt vehicles to only rush-hour service of perhaps 10 to 15 thousand miles yearly. An important consideration is productivity relative to future amortization of the rebuild expense and to future operating and maintenance costs.

The U.S. DOT/UMTA has published interim guidelines on its Bus Rehabilitation Program for transit operators. It provides a basis for receiving transit financial assistance for the rehabilitation of buses. It defines eligibility for assistance, requirements for receiving assistance, and a formula for UMTA's share of total costs. Existing guidelines dated July 1979 (UMTA Notice N-9051.1, "Interim Guidelines: Bus Rehabilitation Program") are currently flexible and under review for possible revision.

The prime candidates for bus rehabilitation seem to be those fleets ranging 12 to 15 years of age, because maximum funds are available to this group by design under the UMTA formula. The number of U.S. transit buses in this age bracket is about 9000, or nearly 20 percent of the U.S. fleet.

UMTA currently limits financial assistance for bus rehabilitation to 100 buses per property, or ten percent of a total fleet, whichever is the greater amount. Buses proposed for rehabilitation must be at least 12 years of age and from a common lot. Rehabilitation should extend bus service life to a total of 20 years, or in the event that the proposed vehicles exceed 15 years of age, rehabilitation must extend service life by a minimum of five years. For each year of service life extention up to eight years maximum, UMTA will provide funds for 80 percent of the rehabilitation cost not in excess of an amount equivalent to 60 percent of the amortized yearly value of a new bus. For example, this means an assistance of $32,000 per bus based on a rehab cost allowance of $40,000 maximum for an 8-year service life extention and a new bus cost of $100,000. UMTA will also participate in the additional cost of wheelchair lift retrofits where such retrofits are feasible.

Terminology in specifications and procurement contracts appears to need more precise definition and understanding. For example, misunderstanding exists over the term "renew" and the requirements for compliance with this term. Lack of uniformity in specifications for bus rehabilitation work will also prevent accurate evaluation of expected bus life extension results and life-cycle costs. Whether uniform rebuild specifications are really needed is not known at this early stage of industry's experience with bus rebuild programs involving outside contractors.

Based on the information developed during this study, there is apparently no consensus on criteria and priorities considered by operators in their decisions on whether or not to rehabilitate buses. Situations differ significantly among operators and reflect some combination of objectives, available funds, fleet composition and condition, new equipment plans, in-house capabilities and political considerations. All operators were found to be preoccupied with alternatives to increase system service capacity. In some instances considerations of political impact may be as important as purely economic concerns.

Local operators consider at least the following factors with varying degrees of priority depending upon local objectives and conditions:

RESOURCES AVAILABLE

- o Available funds, and competition therefore
- o Available buses suitable for rebuilding
  - Age and condition
  - Type of design
- o Rebuild capability, in-house
  - Facilities and available space
  - Available skilled personnel
  - Organization and schedule requirements
- o Rebuild capability of outside contractors
  - Availability and location
  - Competence and price;

BENEFITS AND COSTS

- o Benefits
  - Life extension expected
  - Impact of improvement on service and operations
- o Costs
  - Labor and materials, or total dollars
  - Time buses out of service
  - Risk of future parts scarcity.

The type of vehicle design considered suitable for rebuilding will vary among properties and is dependent upon experience and existing fleet inventory. One property does not consider pre-1966 Flxible Coach models suitable for rebuild because the easily maintained transverse engine-transmission arrangement was not incorporated in Flxible designs until 1966.

E.2 BUS REBUILD CONTRACTORS

Transit bus rebuild contractors in the U.S. are probably limited to four or five firms, most of which are primarily body shops or specialized bus builders.

Transit bus contract rebuilders reported to have significant capabilities include the following firms:

- o Blitz Body Company - - - - Chicago, Illinois
- o NIMCO - - - - - - - - - - - Newark, New Jersey
- o Pacific Bus Rebuilders - - San Ramon, California
- o Hausman Bus Sales - - - - Chicago, Illinois.

The largest of these in terms of rebuild capacity is Blitz Corporation. The Blitz Corporation is a long established repair and remanufacturer of truck and bus bodies and running gear components. Until recently, its principal business was in the wreck-rebuild of transit and intercity buses and trucks, and the manufacture of selected body components. Currently, Blitz is aggressively seeking transit bus rebuild and is expanding its facilities to do so.

The Blitz facilities and organization are located on one site in West Chicago. Employment is currently 250 persons including several subsidiaries. Bus repairs are performed by Blitz Bus and Truck Division. Manufacture and supply of bus body parts are performed by the Interstate Manufacturing and Supply Company, a subsidiary. The main facility is a former heavy truck manufacturing plant ideally suited for bus rebuild activities. Operations including truck repair, bus repair, parts manufacturing, and warehousing are conducted on a 20-acre site with 500,000 ft^2 covered space. A company official states that with two working shifts the firm currently is capable of 500 transit bus rebuilds yearly and that with additional employees and investment, its capacity could reach 1200 units yearly.

E.3 TRANSIT OPERATORS

Transit operators are expected to have the largest share of total industry capacity for bus rebuilds. Nearly all of this capacity rests with no more than 44 operators having fleets of 200 buses and larger accounting for 60 percent of the total U.S. standard size bus fleet, or 30,000 buses. It can be expected that all eight operators of over 1000 buses have potential capability for complete rebuilds. The next 11 operators owning between 500 and 1000 buses likely have capability for partial or full rebuilds. Finally, it is expected that the remaining 25 properties operating between 200 and 500 vehicles will have partial rebuild capabilities to a lesser degree. The remaining large number of transit operators operating 100 or fewer buses tend to farm-out component and bus rebuild work to vendors.

Three transit properties were contacted:

- AC Transit of Oakland, California (850 buses)
- City of Detroit, Dept. of Transportation (830 buses)
- Chicago Transit Authority (2420 buses).

AC Transit provides urban transit services in the Alameda (Oakland) and Costra County areas of San Francisco Bay region. The transit fleet is relatively old with nearly 30 percent being 18 years of age or older. AC Transit currently has on order for delivery in mid-1980 175 New Look design buses by Flyer Industries of Canada. The possible rehabilitation of 50 1961 GMC coaches is under consideration.

City of Detroit, Department of Transportation, provides urban transit services in Detroit proper. The transit fleet is also old, 41 percent being 18 years of age or older. Maintenance and repair facilities include a separate heavy repair facility. City of Detroit (COD) has 1-1/2 years operation on 111 new ADB RTS-2 buses, and is currently taking delivery of an additional 122 units. COD is rebuilding 72 vehicles under an UMTA grant and has initiated a new grant request for an additional 28 rebuild vehicles.

Chicago Transit Authority provides urban transit services in Chicago proper with RTA serving the suburbs. Its transit bus fleet is relatively new with 80 percent of the total fleet being six years of age or less. Maintenance and repair facilities include 10 operating garages and one central heavy repair facility. CTA does not operate ADB buses but plans to purchase 125 new high-capacity articulated buses soon. It may confine future bus purchases exclusively to the articulated buses primarily because of the productivity gain relative to older buses. CTA considered a possible bus rebuild program of 120-150 buses yearly in mid-1979 but has taken no action on the proposal, and the issue is not currently active.

Whether to rebuild buses in-house or through outside contractors seems to depend strictly on the cost alternatives and capability limitations. Due to lower costs and control, operators generally prefer to do rebuild work in-house if unused facilities and space exist. An additional concern here is whether the property should stockpile retired buses or rebuild them under UMTA's recent provision. For example, primarily due to lack of in-house space and manpower, Oakland believes it will use outside contractors. Detroit, on the other hand, has worked out a joint program with an outside contractor wherein the contractor performs the body and structural work and COD performs the component rebuilds and final assembly. Whether possible COD labor credits toward the local contribution were a factor in the rebuild decision is not known, but its possibility must be considered. Chicago has a tentative rebuild program plan which would be performed in-house with an additional 50 personnel. Continuing employment for these persons is a consideration but is not considered a constraint. This plan would require some shifting of existing component rebuild work to a second shift operation.

E.4 SUMMARY

Existing operator and rebuild contractor combined capacity is probably in the order of 500 to 1000 units yearly. Potential capacity may be twice that amount, given adequate facilities, equipment, manpower, organization, and parts procurement sources. The most important constraints appear to be manpower and parts procurement sources.

The principal problems concerning the rebuild of existing buses are related to design obsolescence. Although the continued supply of parts is assured by the original equipment manufacturers for 15 years beyond delivery of the last New Look bus, there is no protection against sharp price escalation on obsolete parts.

Bus rehabilitation does not inherently lend itself to volume production, because industry practice is to repair or replace components on the basis of condition which cannot be fully determined until after contract and partial tear-down. Quality assurance and control require timely and subjective inspections, probably causing lack of uniformity in end results. The remanufacturing process does not lend itself to accurate parts supply and labor requirements planning and, therefore, appears inefficient.

APPENDIX F. ESTIMATION OF OPERATING ASSISTANCE FOR FIXED-ROUTE BUS SERVICE: 1975-80

The National Mass Transportation Act of 1974 made available for the first time Federal transit operating assistance. This appendix derives estimates of the Federal and local assistance that went to urban road transit in the 1975-80 period.

The estimate of Federal operating assistance to urban road transit is based on the assumption that, in the aggregate, bus and rail operations share Federal operating assistance in proportion to their total operating expenses. Table F-1 shows the derivation of total bus operating expense in the U.S. from APTA reported data. For 1975 and 1976, the latest years for APTA's Transit Operating Report, an estimate of total rail operating expense (excluding depreciation) is made by summing the reported expenses of 11 individual operations.* The rail total is subtracted from the total transit operating expense reported by APTA in the Transit Fact Book (excluding depreciation and unfunded expenses) to yield the estimate for total bus operating expense.

The bus expense estimates for 1975 and 1976 are $2.426 billion and $2.805 billion, respectively. This translates to .703 and .722 of total transit operating expenses in 1975 and 1976, respectively. Total rail operating expense in 1977 is estimated at $1.15 billion - an estimated increase of $70 million in rail expense between 1976 and 1977 which reflects the new WMATA operation estimated to have generated $30 million in operating expenses in calendar year 1977. Subtracting the total rail estimate for 1977 from APTA's preliminary estimate for total 1977 transit operating expense yields a bus operating expense estimate of $2.994 billion, or .7225 of total operating expenses.

Multiplying the bus operating expense proportions for 1975, 1976, and 1977 by the total Federal transit operating assistance in those years - $302 million, $423 million and $585 million (reported in Transit Fact Book) -

*The estimate for the MBTA, which does not report total operating expenses by mode, is based on an estimate of $5 per vehicle-mile in 1975 and $5.50 per mile in 1976.

TABLE F-1. TRANSIT OPERATING EXPENSE ($s X 10^6)

	1975	1976	1977P
Total Expense	$3,706	$4,021	$4,305
Less: Depreciation & Amort.	121	136	161
Less: Unfunded Expense[1]	134	--	--
Transit Operating Expense	$3,451	$3,885	$4,144
Rail Transit Operations			
NYCTA	693	710	
CTA	87	98	
MBTA (e)	80	88	
SEPTA	64	67	
BART	49	58	
PATH	34	40	
PATCO	7	8	
GCRTA	5	6	
SHAKER HEIGHTS	3	3	
NEW ORLEANS	2	2	
NEWARK	1	1	
Total Rail Operating Expense (excluding depreciation)	$1,025	$1,080	$1,150(e)
Total Bus Operating Expense	$2,426	$2,805	$2,994
Cost per Bus Mile (cents per mile)	159	177	184

P = preliminary
e = estimate

[1] Total transit operating expenses (excluding depreciation and amortization) exceed total transit operating revenues (from all sources) by $134 million in 1975.

Sources: Total transit operating expenses are from Transit Fact Book, APTA. Rail operating expenses are from Transit Operating Report, APTA.

yields the following estimates of Federal assistance to urban road transit operations in 1975, 1976, and 1977, respectively: $212 million, $305 million, and $422 million.

Local operating assistance for 1975, 1976, and 1977 are estimated by subtracting from total bus operating expense, total bus operating revenues (reported in Transit Fact Book), and the estimate of Federal bus operating assistance as follows (in million dollars):

	1975	1976	1977
Bus Operating Expense	2,426	2,805	2,994
Less: Bus Operating Revenues	1,438	1,486	1,584
Less: Federal Assistance	212	305	422
Local Assistance	776	1,014	988

The estimate of the 1980 Federal assistance to urban road transit is based on a 1980 Congressional appropriation of $1.15 billion for the first two tiers of Section 5 (of the Urban Mass Transportation Act). It is estimated that $50 million of these funds will be spent on capital purchases; the remaining $1.1 billion will be shared between bus and rail operations. The amount of Federal assistance going to rail operations has been estimated for each of the nine urbanized areas that have both rail and bus operations. Table F-2 indicates that of the $400 million in tier I and II appropriations to these multi-modal regions, $250 million is estimated for rail operating assistance. This leaves an estimated $850 million in Federal urban road transit operating assistance for 1980.

The local assistance to urban road transit operations in 1980 is estimated according to the figures and formula which follow. Total operating expense is estimated at $4.5 billion in 1980 based on 1.8 billion vehicle-miles at a unit cost of $2.50 per vehicle-mile; (this is 36% greater than the estimated 1977 unit cost of $1.88 per vehicle-mile.) Operating revenues are estimated at $2 billion based on 5 billion passengers each paying a fare of 40 cents. Subtracting $2 billion in revenues and $850 million in Federal assistance from the $4.5 billion in expenses yields an estimate of $1.65 billion in local operating assistance for 1980.

TABLE F-2. 1980 CONGRESSIONAL APPROPRIATIONS AND ESTIMATED ALLOCATION TO RAIL OPERATIONS

Urbanized Area	Total Tier I & II Funds ($ x 10^6)	Estimated Allocation To Rail ($ x 10^6)	Proportion Allocated To Rail
New York-New Jersey	183	150	0.82
Chicago	66	33	0.50
Philadelphia	40	30	0.75
Boston	22.5	17	0.75
S.F.-Oakland	26.6	10	0.38
Washington, D.C.	23.7	6	0.25
Cleveland	14.7	1	0.07
Pittsburgh	13.9	1	0.07
New Orleans	9.4	2	0.21
	400	250	0.625

Source: Hearings before a Subcommittee of the Committee on Appropriations, Ninety-Sixth Congress.

APPENDIX G. REGULATORY AND LEGISLATED REQUIREMENTS

The last decade has seen an increase in safety and environmental regulations governing motor vehicles. Buses must conform to Federal Motor Vehicle Safety Standards, noise emission standards, and limitations on diesel exhaust emissions. In addition, recent regulations require that transit buses be equipped so that they are accessible to elderly and handicapped riders. The nature of existing and proposed regulations and their impact on transit buses are discussed in this section.

G.1 FEDERAL MOTOR VEHICLE SAFETY STANDARDS

In a bus manufacturing environment in which the builder is responsible for compliance with Federal Motor Vehicle Safety Standards, any substantial increase in the rate of domestic bus production could be constrained by difficulties in complying with new or revised safety standards (along with other regulatory requirements like emissions and fuel economy regulations). To determine the likelihood of this constraint becoming significant, it is necessary to examine new or revised regulations that may come into effect in the next four or five years.

Table G-1 gives the status of a number of regulations that have an impact on transit bus production. Of these, those dealing with bus components that ordinarily are supplied by independent manufacturers are unlikely to provide substantial problems for scaled up production (batteries, tires and rims). Others that deal directly with aspects of bus design (direct and indirect fields of view, braking systems) are not expected to cause much difficulty for transit bus builders, according to NHTSA's Office of Vehicle Standards, Crash Avoidance Division.

Note also that one recently proposed standard that was expected to have a major impact on transit buses, Flammability of Interior Materials, has been dropped from consideration because of loudly voiced criticisms of unreasonable cost. It will now pertain only to school buses. Other issues remain on the NHTSA agenda for longer-term exploratory research which may or may not lead to additional safety standards being proposed: Upgraded Performance of Brakes, Tire Traction, Tire Inflation Pressure Warning, Electromagnetic Interference,

TABLE G-1. IMPACT OF CHANGES IN THE FEDERAL MOTOR VEHICLE SAFETY STANDARDS (FMVSS) ON TRANSIT BUSES

Standard	FMVSS Number	Status	Comments
Air Brake	130,(121)	In effect	One aspect of the revised #121, pertaining to an anti-lock feature, was overruled in court. Remaining aspects never in question will appear in a revised form, new 130.
Hydraulic Brake	105	Proposed	Current standard applied to school buses will be extended to other buses, effective 1984.
Direct Fields of View		Proposed	Effective Model Year 1982, there will be limits to the obstructions a vehicle creates to the driver's direct view.
Rearview Mirror Systems		Proposed	Effective Model Year, 1982, mirrors must provide driver a fixed percentage of view behind or on both sides of vehicle
Battery Explosion		To be Proposed	Standard will reduce the chance of lead-acid explosion in all vehicles, effective 1981 model year.
Tire Selection	120	Amendment	Require tubeless tires and a certain type of rim for all vehicles but passenger cars.

Note: The information in the table above was obtained largely from the NHTSA Five Year Plan for Motor Vehicle Safety and discussions with NHTSA officials.

Reliability, Standardization of Controls and Displays, Speed Control Devices, and Lighting and Marking. These remain long-term concerns, however, and are unlikely to be brought to a rulemaking stage before 1985.

G.2 NOISE EMISSION STANDARDS

On 29 August, 1977, the U.S. Environmental Protection Agency issued Proposed Noise Emission Standards for Buses. These regulations though dormant for several years may be promulgated by mid to late 1980. When initially issued, the proposed standards were applicable to all buses having a Gross Vehicle Weight Rating (GVWR) in excess of 10,000 pounds. The standards would, therefore, cover school, transit and intercity buses. Staged reduction in regulated noise levels were planned as follows:

1 January 1979	83 dBA exterior	86 dBA interior
1 January 1983	80 dBA exterior	83 dBA interior
1 January 1985	77 dBA exterior	80 dBA interior.

With the passage of time and the delay in final promulgation of the EPA standards, it is possible that the initial regulation step will now be the 80 dBA exterior/83 dBA interior step and that the implementation data will be 1 January 1983. If this is the case, the impact of the regulation on new transit buses is not expected to be severe. In any case, without engineering effort and significant field testing, the 1 January 1985 level may be difficult to achieve. A regulated level of 77 dBA exterior requires a manufacturer to design to a level of 75 dBA to insure compliance of production vehicles. Also, if noise abatement is obtained with add-on covers and other devices not necessary for bus operation, these devices may not be retained during bus maintenance because of the added costs of removal and replacement.

There are other problems for transit bus manufacturers and operators associated with the proposed bus noise testing procedure. It would be desirable to encourage manufacturers to bias noise toward the left side of the bus away from the adjacent sidewalk. In similar manner, the noise reduction benefits and energy saving feature of demand actuated fan drives could also be encouraged. The possibility of the need to reduce diesel bus noise three to five dBA lower than the proposed final standard has been indicated in studies made by GM, TRI-MET and others due to the increased use of transit malls in central business districts. Bus noise levels as low as 72 dBA may be required. A standard as high as 77 dBA may preclude the use of large buses in these urban malls.

G.3 EXHAUST EMISSION STANDARDS

G.3.1 Regulated Emissions

The Clean Air Act Amendments of 1977 require reductions in exhaust emissions from heavy duty engines for carbon monoxide (CO), hydrocarbons (HC), and nitrogen oxides (NOx) and establishes a particulate matter mass emission standard. Specifically, the Amendments require a 90 percent reduction in CO and HC emissions beginning in model year 1983 and a 75 percent reduction in NOx beginning in model year 1985. Base year for calculating CO and HC reduction is 1969 and 1973 for calculating NOx reductions. Particulate matter is to be regulated beginning with model year 1981.

The Environmental Protection Agency has proposed a major change in the emissions certification test procedures for heavy duty engines. Currently, all heavy duty engines are certified by a steady state test procedure termed the "13 mode" test. EPA has proposed a "transient" test procedure beginning with model year 1983 that it claims will more accurately represent on-the-road performance.

The Clean Air Act Ammendments of 1977, Sections 202 (a) (4) and 206 (a) (3), place the burden of proof on the manufacturer to establish that emission control systems or elements of design used in new motor vehicles or motor vehicle engines do not cause or contribute to an unreasonable risk to public health, welfare, or safety before certificates of conformity may be issued. Without a certificate of conformity, the bus or any motor vehicle may not be offered for public sale.

The amount of reduction in exhaust emissions required by the Clear Act Act Amendments of 1977 will be difficult, at best, for heavy duty diesel manufacturers to meet. Representatives for the industry have stated publicly that they know of no technology that will allow 90 percent reductions in CO and HC and 75 percent reduction in NOx while maintaining fuel efficiency, performance, and durability. At the present time, EPA's position regarding their proposed transient test procedure and the 1981 model year particulate standard is uncertain.

G.3.2 Unregulated Emissions

Diesel engines have the propensity to emit exhaust products that are odorous and display the tendency to irritate the eyes and nasal passages. The exhaust odorants and irritants are generally considered to be a nuisance rather than a direct health risk. This is not the case with diesel exhaust particulate emissions.

During the past 2-1/2 years, questions have surfaced in public passenger automobile Fuel Economy Hearings, the press, the automotive industry, and within the Federal Government on the potential health hazards of diesel exhaust particulate emissions. Work in progress at EPA-Research Triangle Park has tentatively concluded that the organic fraction of the diesel exhaust particulate contains compounds that are mutagenic and, therefore, potentially carcinogenic. EPA has initiated a significant health effects research effort concerning diesel exhaust emissions. During the past twelve months, the Department of Energy (DOE) has also initiated a research program regarding major diesel health effects.

It is generally conceded that the EPA's and DOE's testing of diesel particulate organic extract will show tumor formation in some animal types at some concentration. For example, the animals used for the skin painting tests are highly susceptible to tumor formation and have a finite, spontaneous tumor formation rate, even in the control group. Diesel particulate organic extracts will be applied in concentrations higher than the potential exposure of humans to whole diesel particulates. The important consideration centers on the actions to be taken by EPA upon finding tumor formation from diesel particulate organic extracts.

It has been suggested that EPA will not apply a Delaney Clause-type ruling to diesel engines in motor vehicles. A strict application of a Delaney Clause-type* to diesel engines would require the immediate banning of all diesel engines, clearly a significant and disruptive decision. The path most likely to be chosen by EPA will utilize the Clean Air Act Amendments of 1977, Sections 202(a) and 206(a) (3).

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*Delaney Clause of the Food, Drug and Cosmetic Act requires that any food additive shown to cause cancer in reasonably conducted laboratory tests on animals must be removed form the market.

G.4 IMPACT OF FEDERAL REGULATORY REQUIREMENTS ON IMPORT OF FOREIGN BUSES

A possible solution to the problem of limited availability of American transit buses is the purchase of foreign buses. However, U.S. regulatory standards may limit the sale of foreign buses in the U.S.

E.P.A. emission requirements potentially have the greatest impact on the viability of imported buses in the U.S. market. Because such requirements relate directly to the engine, power and gross weight of the vehicke, such standards are not easily skirted by cosmetic adjustments to buses already being manufactured for use in Europe or elsewhere. Pollution control requirements, which are generally stricter in the U.S. than in other developed nations, might be sufficient to require the installation of improved emission-control devices, which might not be available or compatible with the design of foreign buses.

The Federal Motor Vehicle Safety Standards present another layer of regulation that might either prohibit or discourage the import and use of foreign transit buses. Articulated transit buses now in use in the U.S. are manufactured largely in Germany but outfitted for final sale in the U.S. The technique of assembly in the U.S. allows the opportunity for the buses to be modified to meet the FMVSS. Many of the more superficial standards can be met by the installation of U.S. componentry (e.g., lights, batteries, windshield wipers) that do meet the FMVSS. Other standards are more closely tied to the basic design of the bus, with the window location determining visibility and more basic structural components determining weight, handling, speed capabilities, braking. This second group of standards may require costly engineering changes, so buses that fail to meet these more demanding standards will not easily be brought to the U.S. market, even after some refitting.

The willingness of both the buyer and manufacturer to incur the extra costs of bringing foreign buses into compliance with U.S. requirements will determine whether or not it is feasible to sell foreign buses in the U.S. A more detailed analysis would attempt to assess these costs in the light of any market factors or political considerations that might more immediately determine how foreign buses could be bought and used in the U.S.

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