TSC-UMTA-77-16 Ref

NO. UMTA-MA-06-0079-77-1

TRANSIT INTEGRATION

REAWIDE Demand·Responsive Transportation System

PROGRAM SYNOPSIS

DOCUMENT IS AVAILABLE TO THE U.S. PUBLIC THROUGH THE NATIONAL TECHNICAL INFORMATION SERVICE, SPRINGFIELD, VIRGINIA 22161

Prepared for

U. S. DEPARTMENT OF TRANSPORTATION
Urban Mass Transportation Administration
Office of Technology Development and Deployment
Office of Bus and Para Transit Technology
Washington DC 20590

Technical Report Documentation Page

eport No.	2. Government Accession No.	3. Recipient's Catalog No.
ITA-MA-06-0079-77-1		

itle and Subtitle
ARATRANSIT AND TRANSIT INTEGRATION AREAWIDE
EMAND RESPONSIVE TRANSPORTATION SYSTEM--
ROGRAM SYNOPSIS

5. Report Date
April 1977

6. Performing Organization Code

8. Performing Organization Report No.
DOT-TSC-UMTA-77-16

uthor(s)

ldon Ziegler, Robert Hubbard

erforming Organization Name and Address
.S. Department of Transportation
ransportation Systems Center
endall Square
ambridge, MA 02142

10. Work Unit No. (TRAIS)
UM728/R7705

11. Contract or Grant No.

13. Type of Report and Period Covered
Program Synopis
Jun'76 - Jan'77

Sponsoring Agency Name and Address
.S. Department of Transportation
rban Mass Transportation Administration
ffice of Technology Development and Deployment
ffice of Bus and ParaTransit Technology
ashington, DC 20590

14. Sponsoring Agency Code

Supplementary Notes

Cover photos courtesy of the Rochester-Genesee Regional Transit Authority

Abstract

The Urban Mass Transportation Administration carries out re-
earch and development on Areawide Demand Responsive Transportation
AWDRT) systems as part of the Bus and ParaTransit Technology ac-
ivities. AWDRT systems are basically the integration of flexibly-
outed paratransit with fixed-route transit resulting in increased
overage for public transportation. The AWDRT R&D Program is to
levelop critical information, procedures and technology now needed
o provide the foundation and to assess the potential for evolution
of today's fixed-route transit to areawide systems. The program
onsists of the following elements:

- Analysis and assessment of past and current AWDRT experience
- Advancement of AWDRT system design
- Advancement of AWDRT technology
- Dissemination and evaluation of research results and guidelines.

This program is divided into two phases with the major deci-
sion point occurring after FY 77 activities. Both phases of the
program, which are subject to change as requirements evolve, are
described.

Key Words	18. Distribution Statement
ParaTransit, Areawide Demand Responsive Transportation (AWDRT), Dial-A-Ride	DOCUMENT IS AVAILABLE TO THE U.S. PUBLIC THROUGH THE NATIONAL TECHNICAL INFORMATION SERVICE, SPRINGFIELD, VIRGINIA 22161

Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified		

AREAWIDE DEMAND RESPONSIVE TRANSPORTATION SYSTEM

1.0 System Description

1.1 Introduction

As Metropolitan areas have changed from a primarily urban environment to include ever increasing suburban communities, regular transit has found itself serving a rapidly shrinking proportion of the population. As a result, the need to provide low density service has become a significant problem. This low density service is particularly applicable in the suburbs, for the transit disadvantaged, at nights and on weekends. While such service is inevitably more expensive than downtown high density service, conventional fixed route bus or rail modes are the most expensive and least appropriate to serve these new markets that have low demand volumes and dispersed travel patterns. Transportation systems are urgently needed which integrate the best of conventional transit and new flexibly routed demand responsive paratransit into an areawide service.

Suburban travelers are illustrative of todays transportation problems. Approximately 80% of all trips both begin and end in the suburbs. Yet single person automobile trips that lead to congestion and adverse environmental effects in the central business district as well as large energy usage, begin in the suburbs. Suburban areas contain 43% of our population; have significant transportation needs for the elderly, young, handicapped and poor as well as women working in the home. Also, the middle to lower income family, which pays a large part of urban taxes, is joining those with lower incomes in feeling the effects of the rising costs of owning and operating multiple private automobiles.

Policy and practice at Federal, state and local levels strongly support the need for greatly improved transportation to meet these needs with the emphasis on areawide demand-responsive transportation. As a result of this policy, there is a need for more data on this type of service, on the costs and applicability of its flexibly routed paratransit modes and on methods of scheduling these services and integrating them with conventional transit. This policy posture is illustrated by the following:

- The National Mass Transportation Act of 1974 declared transportation systems integrating several modes to be in the national interest;

- The transportation policy statement by the Department stresses improved accessibility to all citizens, cost/effective mixes of modes appropriate to each urban area and low capital intensive improvements;

- The Department's regulations on Transportation Improvement Plans require consideration of demand-responsive services in low density areas, greater flexibility and responsiveness in routing, scheduling and dispatching of transit vehicles and the integration of flexible paratransit services in the public transportation system;

- The proposed policy on Major Urban Mass Transportation Investments requires analysis of alternatives including the integration of modes tailored to the specific needs of neighborhoods and improved management of the existing transportation system with specific mention of the promotion of paratransit service;

- Michigan is actively funding demand-responsive services throughout the State with 28 localities already running new services;

- Three urban areas have started pilot areawide demand-responsive transportation systems;

- Demand-responsive services have proved effective for the transit disadvantaged and

- Nearly 100 small urban areas have found demand-responsive an effective and efficient service.

Further, the Williamsburg Conference on Paratransit endorsed the need for integrating conventional transit and paratransit but found that much more information is needed prior to widespread deployment of integrated areawide systems. The R&D program as described in this paper will provide the needed information.

1.1.1 Definition of Areawide Demand Responsive Transportation (AWDRT)

An Areawide Demand Responsive Transportation (AWDRT) system is basically the integration of flexibly routed paratransit services with a fixed route service resulting in increased coverage for public transportation. The major features of AWDRT are flexibility, integration of services and the use of automation for more efficient operation. In peak hours subscription buses will compliment car pools, van pools and conventional transit for service to suburban as well as CBD employers while flexibly routed vehicles will provide feeder service to conventional fixed route buses and, where available, rapid rail lines. During the day the small flexibly routed vehicles will serve shopping trips, the transit disadvantaged and as feeders to line-haul fixed routes with longer headways. At nights and on weekends flexibly routed services are expanded as fixed routes are shortened providing improved safety and door-stop service.

The basic operation of the AWDRT service involves dispatching a vehicle in response to a telephoned request for service to carry the patron to his destination, while simultaneously accommodating in the vehicle other patrons whose requests for service are compatible in terms of both time and geography. The actual number of intermediate stops made between the origin and destination of a particular passenger will vary with the pattern of demand responsive transportation service offered, the time of day, the capacity of the vehicle, the level of service offered, and other parameters of a particular service.

The basic elements of a demand responsive transportation service are shown in Figure 1 and are: a fleet of vehicles, a means of communication between the patron and the service, a means of communication between the service and the vehicle drivers and a control center to receive requests for service and schedule and dispatch vehicles. Around these basic elements, the concept of demand responsive transportation service lends itself to a variety of configurations in terms of organizational character, degree of automation, equipment, work force, service patterns, size of service area, and market role. The basic approach in applying demand responsive concepts to an area is to divide the urban areas into community size modules as shown in Figure 2 which can then be integrated with line haul fixed route services.

TOMMORROW'S TYPICAL TRANSIT

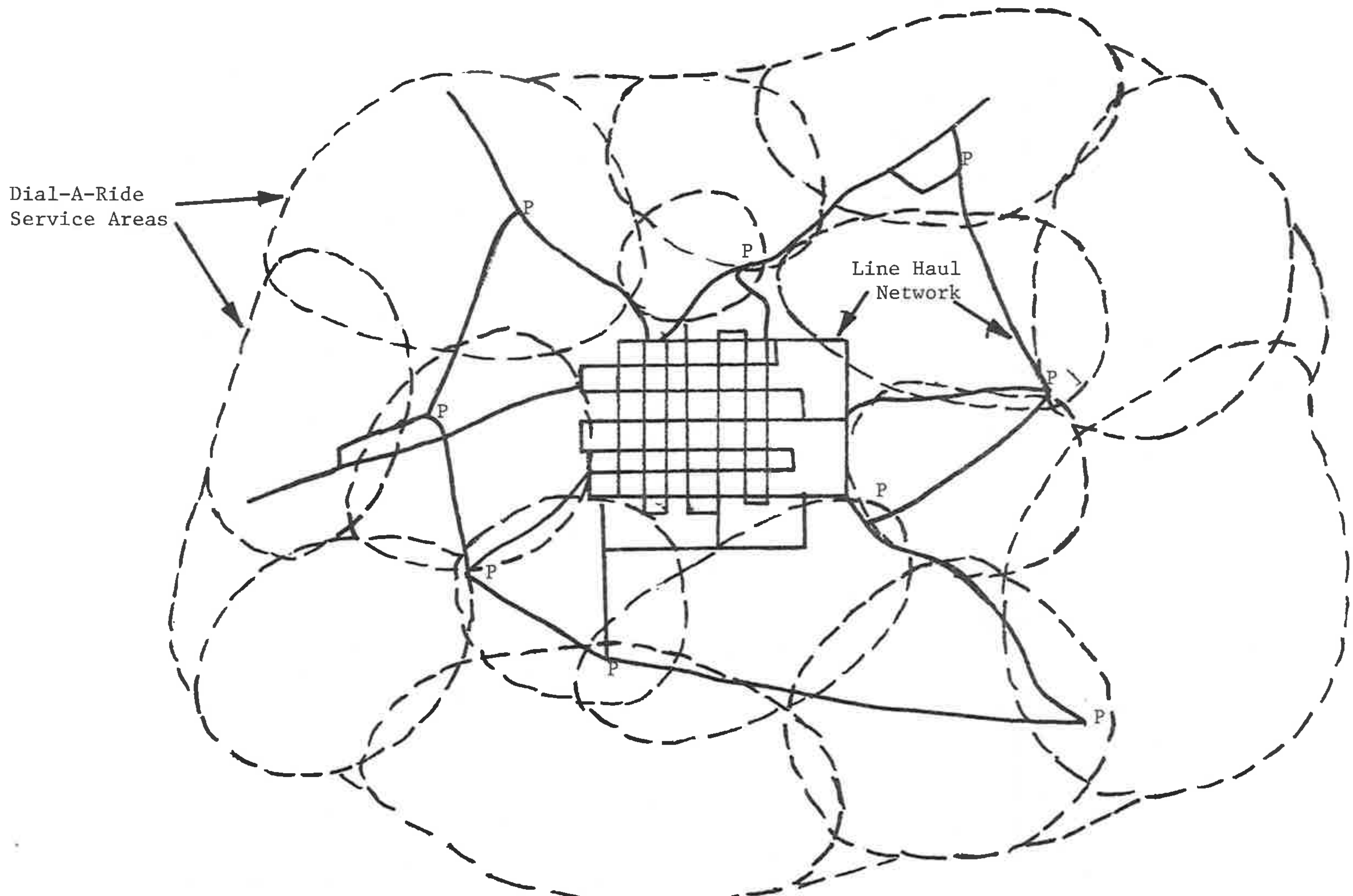


FIGURE 1.

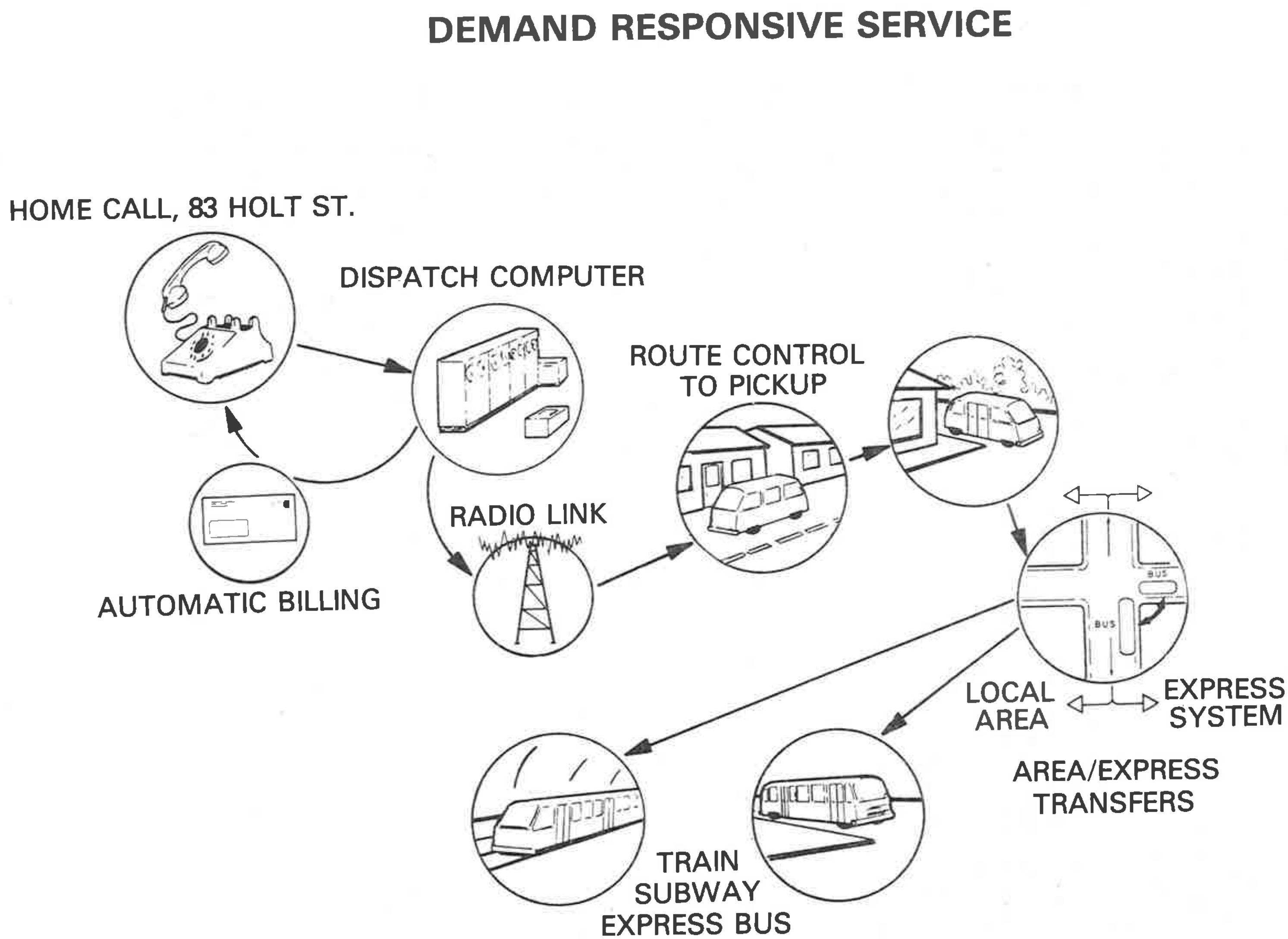

DEMAND RESPONSIVE SERVICE
HOME CALL, 83 HOLT ST.
DISPATCH COMPUTER
ROUTE CONTROL
TO PICKUP
RADIO LINK
AUTOMATIC BILLING
LOCAL
AREA
EXPRESS
SYSTEM
AREA/EXPRESS
TRANSFERS
TRAIN
SUBWAY
EXPRESS BUS

FIGURE 2.

1.1.2 Applicability of AWDRT to Transportation Needs

The concept of areawide demand responsive transportation is directly applicable to 93% of the urban area, those up to 1.5 million in population, to small communities and for rural service. It has the greatest potential for providing improvements in public transit in the near term and is a strong candidate for solving many of the future transit needs of larger urban regions. It is the most suitable of the many possible alternatives for meeting the diversity of transit needs discussed previously. AWDRT is not intended to replace the private automobile as the primary transportation mode, but rather can effectively complement car pools, van pools, and conventional transit, as well as provide flexibly routed feeder transportation in order to provide the additional needed service.

1.1.3 AWDRT Cost Benefit

In principle, a benefit/cost analysis would develop dollar values in each future year for the quantifiable benefits and costs of the program. Such an analysis would require that scenarios be developed describing the implementation of AWDRT, predicting the impacts of AWDRT in all the implementation areas, and attributing dollar values to the associated benefits and costs.

Such an analysis is not now available. In fact, one of the program elements provides for doing benefit/cost analyses. Instead, a qualitative description of the benefits and costs of AWDRT is presented in the following paragraphs that reflects the best understanding at the present time.

Economic Benefits

One potential set of benefits for an AWDRT system is economic. In this context, there are two basic benefits to be derived from further development of these systems:

- Flexibly routed, demand-responsive systems are the most economical way known to provide low ridership density service of adequate quality if such service is desired. This cost advantage over conventional fixed-route transit can be further increased through R&D leading to better planning, more efficient routing and scheduling, and an optimum mix of flexible and fixed route based on a tradeoff between the two modes.

- The integrated and cooperative operation of conventional fixed route transit and flexible route demand responsive service in the AWDRT concept offers promise of lowering the overall per passenger cost of public transit, and in the longer term of reducing the rate of growth of transit deficits and the possibility of reducing the absolute levels of transit deficits.

At this stage, this latter point can only be conjectured on the basis of analysis and not on experience. But it is a very important prospect even though it can not be proven without actual testing. Operating deficits with conventional transit have grown to more than a billion dollars annually with no other prospect on the horizon for significant improvement. In cooperation with the Service and Methods Demonstration Program, the AWDRT program will support the actual testing of this integrated concept and provide data on this very important possibility.

In addition to the potential of improving overall urban transit system service and minimizing the growth of deficits and even possibly reducing deficits, AWDRT is also a high potential and low-capital intensive approach to improving urban transit. Other approaches, such as conventional fixed urban rail or networks of dedicated new technology systems require greater capital commitments, have longer development lead times, and appear appropriate in configurations of high transit demand. Since long term demographic trends are toward lower urban densities, systems appropriate for lower densities may be both less risky from a financial point-of-view but may also be more appropriate for evolving future demographic conditions than other more capital intensive approaches. Furthermore, a successful AWDRT service by increasing ridership on the fixed route system would have valuable catalytic effects on the financial viability of the more costly, fixed route capital intensive systems.

Social and Institutional Benefits

In addition to the financial benefits, there are important social and institutional benefits of AWDRT which are described below:

- <u>Lowest cost alternative for specialized services</u>

  Flexibly routed, demand-responsive systems are presently thought to be the lowest cost alternative known for specialized services, such as special services for the elderly, handicapped, or poor.

- <u>Service area flexibility leads to enhanced potential for community acceptance</u>

  Modular design of flexibly routed, demand-responsive systems assists in utilizing multiple operators (including taxi operations) and in charging for the cost of service provided (i.e. the community can decide whether one group should cross-subsidize transportation for other groups). Furthermore, in contrast with fixed route service, everyone in the service area perceives an equal level of service. This would probably lead to an increased local willingness to pay needed subsidies.

- <u>Reduced costs of urban transportation</u>

  AWDRT promises to reduce total cost of urban transportation by reducing the need for today's almost total reliance on private autos with its attendant effects of reduced congestion and land used for parking.

- <u>Increased mobility for urban residents</u>

  AWDRT may significantly expand the mobility of urban residents by providing transit service where none presently exists and also could be used to improve local collection and distribution and off-peak service where service is presently commuter oriented.

- <u>Enhanced viability for taxi operations</u>

  AWDRT may relieve the current erosion in the financial viability of taxis caused by the present inflation of labor and fuel costs not offset by rate increases for taxi use.

- <u>Increased employment in AWDRT areas</u>

  New drivers, maintenance crews, dispatchers and first level supervisors would be needed, providing opportunities for entry level positions in transportation. Additionally, an expanding market for small vehicles can be expected to provide jobs in production of the vehicles.

Flexible route services are more appropriate systems to meet certain travel needs and thus are expected to attract more riders than conventional transit services. Elderly and handicapped people need service within two blocks of their residences and many would benefit from door-stop pick-up and delivery. A 1973 study by TSC estimated the number of urban people in this category that could use public transportation:

- For urban handicapped and elderly non-drivers

  - transit available within 2 blocks

    4.6 million persons

  - transit not available and could use it if it were

    3.0 million persons

- Urban handicapped and elderly drivers

    4.4 million persons

Thus, AWDRT systems will have a considerable utility to meet the handicapped and elderly transportation needs.

While we believe that demand responsive transit service can provide better service than conventional transit, a major issue is the financial viability of these systems in terms of community willingness-to-pay. It is clear from both experience and theory that the costs per hour for demand responsive systems is either about the same as fixed route or less if private operators can be used. Since we expect that ridership will be higher on demand responsive systems, the cost per passenger will be lower. Specifically, demand-responsive services can have higher productivities than fixed routes in suburban areas. Fixed routes have very low productivities during off-peak hours in the low density suburbs. For example, the average productivity (including peak hours) for a sample suburban Washington, D.C. fixed route line has been 10 passengers per vehicle per hour weekdays and 1.6 on Sundays. The average weekday cost is over $2.00 per ride and the Sunday cost over $12.00 per ride. The productivities of the three fixed route lines in Haddonfield, New Jersey during the mid-day period were as low as 4 passengers per vehicle per hour, $4.30 per ride in 1973, and no higher than 12, $1.40 per ride.

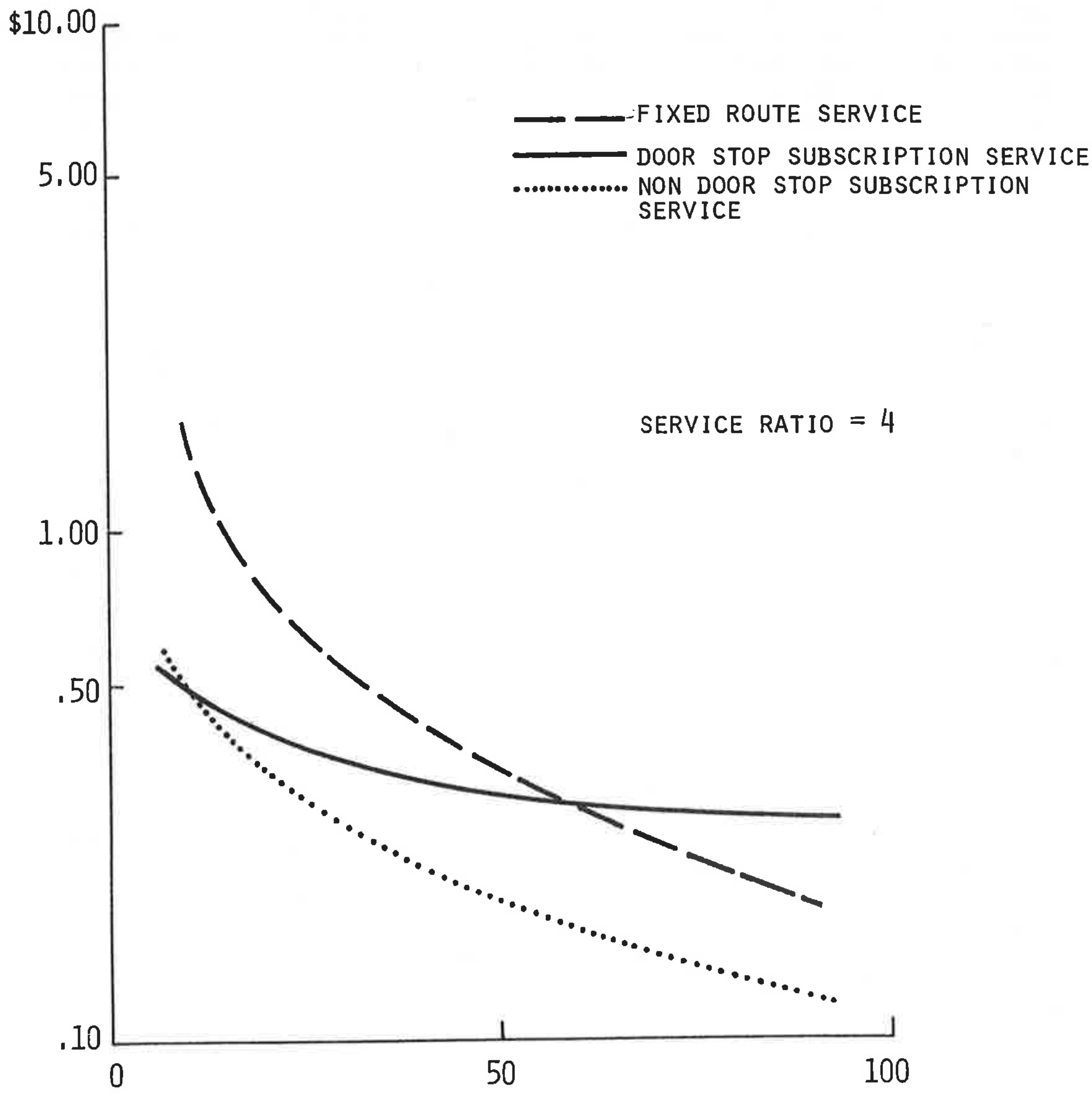
In comparison, even with broader coverage and the higher quality, door-stop, non-transfer service, demand-responsive productivities average from 5 to 10 passengers per vehicle per hour and services with transfers have averaged from 15 to 20 passengers per vehicle per hour. The Haddonfield Dial-a-Ride productivity of 7.3 exceeded the productivities of two of the three fixed routes in Haddonfield. The Haddonfield Sunday productivity of 5 is three times that of the Sunday fixed route line in suburban Washington; a cost reduction of 3 to 1 with public transit operation and 6 to 1 with private operation.

In addition, a TSC theoretical study found that in general a flexible route subscription bus service may be more efficient than a fixed route service in providing good feeder service based on passengers carried per vehicle hour. Figure 3 is based on translating ridership into cost per passenger. It indicates that at low demand, which is typical of today's suburbs, door stop service has the lowest cost per ride while at higher demand, subscription service with a short walk by the user has the lowest cost. At all likely demands, flexible route, door stop or non door stop is the least costly feeder mode for even a medium level of service.

While the financial viability of both low density services, fixed or flexibly routed, is in doubt, flexibly routed services appear to be the more viable. Current local initiatives in demand responsive systems illustrate the interest in testing the viability of these services.

With respect to easing some of the institutional problems in urban transportation, AWDRT service areas can be shaped to conform to political boundaries. This is a strong advantage for AWDRT over fixed route transit since everyone in the

COST PER PASSENGER



DEMANDS PER SQ. MILE PER HOUR

FIGURE 3.

service area would perceive the same level of service in contrast with fixed route transit. This feature may make the use of local taxes for subsidies for AWDRT more feasible than for fixed route transit.

In addition, some households may find the cost of auto ownership excessive but need low cost transportation to jobs and facilities. Suburban travel with its diversity of origins and destinations typifies conditions under which small flexibly routed vehicles can provide better service than the conventional transit. Therefore, widespread acceptance of AWDRT could lead to reduced auto ownership (possibly attendant reduced energy use) and improved urban land use (reduced need for parking facilities and condensed urban form).

Furthermore, AWDRT could result in increased mobility for urban residents with its attendant social and economic benefits. Present transit service is commuter oriented. AWDRT would enhance commuter service and improve local transportation for all other functions including shopping, social, medical, and recreational purposes. While we can not presently measure the size of the economic benefits resulting from this mobility, it is our opinion that they are both favorable and significant. Clear, significant benefits are potentially available to the drivers who previously chauffered the non-drivers as well as to the non-drivers who no longer need to rely on the drivers for their mobility.

Conventional taxis are a readily available form of demand responsive service. But taxis are often limited to exclusive ride services and, thus, suffer the lowest productivity of all demand responsive services. Only low wage rates keep taxi costs competitive; but taxi wage rates are rising faster than fares and low density taxi services could disappear as low density transit has disappeared. Integrating taxis into public transit services could further increase the upward pressures on wage rates. Higher productivity of taxis is needed to offset increasing costs. The best known method of substantially increasing taxi productivity is to incorporate Dial-A-Ride sharing techniques. Existing shared-ride taxis surveyed recently have twice the productivity of conventional taxi; but only half the productivity of many public Dial-A-Rides. In California, Michigan, and Iowa, taxi operations are running

Dial-A-Ride for cities resulting in some of the lowest cost services.

Clearly, a successful AWDRT would create some jobs in communities. Therefore, such systems would be attractive to areas with high unemployment rates. The system could create local jobs and, in addition, may increase job opportunities for those with mobility barriers to employment. Another advantage of these jobs is that they require skills that are widely available.

Finally, there are signs of public acceptance of AWDRT in small communities with the public acceptance being tangibly demonstrated by a willingness of some local governments to subsidize the service. In their view, the social and economic benefits are worth the cost. The question that this program will attempt to illuminate is whether AWDRT can also be successfully integrated into the transit systems of larger cities.

The Costs (and Risks)

In contrast to the benefits discussed above, the AWDRT program has attendant costs, Clearly, one cost is the cost of the R&D program itself. Another is that Dial-A-Ride, where it is run in competition with taxi operations, may lead to destructive competition between them. A third, is that AWDRT may develop into a service with increasing deficits and demands for Federal subsidies. Reduced auto ownership would lead, to some degree, to reduced employment and sales in the auto industry, but changes in auto sales and employment are not expected to be substantial and may simply somewhat reduce long-term growth trends in auto sales. Finally, it is possible that even successful AWDRT may require considerable local subsidy which may deflect funds from other needed public services or private consumptions.

In summary, AWDRT is a way in which urban transportation services could conceivably be improved and costs reduced with minimal lead time, investment at risk, and associated urban disruption compared to other more capital intensive approaches (e.g., urban rail or highly automated new technology systems). Whether the promise can be realized, can be determined most efficiently by R&D. If, indeed AWDRT meets the potential visualized by its advocates, the benefits would be so large (even in terms of reducing deficits compared to what they may otherwise be) that R&D costs would appear trivial in comparison. If AWDRT is not what its advocates had hoped for, then the information developed in this R&D program is the most efficient way to make its real potential known and minimize losses.

1.2 Program Goals and Requirements

The goals of Areawide Demand Responsive Transit Program are as follows:

- provide for the incremental and evolutionary growth from existing conventional transit systems into integrated areawide systems.
- provide high quality service to attract riders while remaining responsive to local objectives and economics.
- maximize the productivity of the overall transit system to increase system revenues and stabilize or reduce user fares.
- provide greatly increased transit service for all segments of the urban population especially for the transportation disadvantaged.

These goals can not be met by any one transit mode alone. However, a combination of fixed route services for long trips and in high ridership density areas and flexible route services for low ridership density areas and broad coverage conditions can satisfy the above goals.

The deployment of areawide systems is to be accomplished by the local agencies and the planning and deployment of such systems has begun on a limited scale by several communities. However, before communities can make effective use of the AWDRT concept, the following major requirements must be satisfied.

a. The service and cost characteristics of AWDRT must be established for various size systems such that rational decisions can be made on the benefits to be derived from these deployments;

b. Solutions to the critical technical problems of passenger scheduling, vehicle dispatching, fleet management and system performance evaluation must be developed through R&D and proven through the service and methods program;

c. The capacity and productivity of AWDRT must be improved while the costs are reduced;

d. System design information, procedures, and/or specifications must be available that can be used by the planners, developers and users of the AWDRT system to assist in the implementation and to avoid costly mistakes.

1.3 Program Objectives

The Areawide Demand Responsive Transportation R&D Program is directed towards the development of critical information, procedures and technology which provide the foundation for the successful evolution of today's fixed route transit to areawide systems. The program is not directed toward the development of complete deployable systems, but rather toward the development of elements supporting a variety of deployments through UMTA's Service and Methods Demonstration Program and local initiatives. An example of the development effort would be the development of software for a generalized control system in which the local agency could build on for the specific computer and site-specific applications.

Specific objectives of the program are:

a. Evaluate in detail the service and operating costs and benefits of AWDRT systems in a wide variety of applications.

b. Develop methods of estimating the demand, costs, fleet size, performance, computer requirements and communications capabilities for designing new or expanded areawide systems.

c. Develop a comprehensive family of simulation models capable of evaluating the performance of proposed system configurations, fleet deployments, computer systems and communications facilities prior to actual operation.

d. Design and validate scheduling methods, operational procedures and integrated fleet management capabilities to increase the productivity and reduce the cost of areawide systems.

e. Develop, test and improve critical computer control system scheduling, dispatching and performance evaluation algorithms and computer software for AWDRT systems including shared-ride taxi service.

f. Assess the economic, technical and operational impact of large modal splits on areawide systems.

g. Develop operating strategies for application to unique local conditions to improve productivity for local, short distances, flexibly routed services, commuter and other peak period services, line haul and other off-peak long distance urban services.

h. Define deployment concepts, assess the technical requirements, estimate the costs and benefits and determine the research and development requirements of large regional applications of areawide systems.

1.4 AWDRT Program Outputs

The output data and analytical tools obtained from each of the program elements described in paragraph 1.5 will be extensively documented through reports on each of these elements. It is anticipated that some of the results developed in these tasks may change the scope and nature of tasks and the correlation between task areas. Annual reports will be prepared to summarize the progress made in the AWDRT development program. Workshops will be conducted as appropriate to obtain and disseminate data to system designers and urban planners. Data, techniques, and guidelines evolving from the program will be applicable to a broad spectrum of systems, ranging from local demand-responsive service to totally integrated areawide systems. The R&D products resulting from this program will have broad application. These applications and the typical products are listed in Table 2 with the specific program outputs and estimated delivery dates listed in Table 3.

1.5 AWDRT Program Elements

The critical information, procedures, and technology necessary for the eventual evolution of today's fixed route transit to a totally integrated areawide system have been grouped into five major areas which are:

1. Analysis and Assessment
2. System Design
3. Technology Development
4. Dissemination and Evaluation
5. Program Support

Each of these areas contribute to a time phased incremental development of the AWDRT program such that the program outputs are available at various stages of the program depending on the degree of implementation of AWDRT. The program is structured such that currently known transit industry needs can be addressed in design, development, and test areas simultaneously with critical tasks in analysis and assessment. This structuring provides for near term payoffs from the program.

The five program elements are described in more detail below:

.5.1 Analysis and Assessment

The analysis and assessment element is divided into four tasks:

a. Cost/benefit analyses

b. Review and assessment of operational experience

c. Increased productivity

AWDRT Products

- **Policy and Program Analysis**
  - Cost Benefit Studies
  - Large Region Impact
  - Assessment Methodology
  - Design Studies of Large Region Systems
  - Laboratory for Initial Concept Evaluation

- **Local Planning and Development Support**
  - Assessment of Previous Experience
  - Planning and Implementation Handbook
  - Demand/Fleet Size/Cost Estimation Tools
  - Sample Vehicle and Computer Specifications
  - Site Selection Criteria
  - Increased Productivity Methods
  - Computer System Test Plans

- **Demonstration Program Support**
  - Analysis Tools and Simulation Models For Evaluating Demonstration Results
  - Computer Software for Improved Scheduling and Dispatching
  - Management Information Tools for Measuring Operational Results

- **Technology Qualification**
  - Criteria for evaluating private industry system developments
  - Simulation models to assess performance

- **State of the Art Technology**
  - Computer control algorithms and procedures for integrated Dial-A-Ride and fixed route systems
  - Generic Computer Software for AWDRT
  - Computer Control Systems requirements and generic software for Shared-Ride Taxi System
  - Improve communication with customers and system vehicles

TABLE 2

LIST OF DELIVERABLES

PROGRAM AREA	PROGRAM ELEMENT	PROGRAM PHASE	DELIVERY DATE
ANALYSIS			
Cost Benefit Analysis	3.1.1	I	Dec. 1977
Large Region Impact Analysis	3.1.1	I	July 1979
Increased Productivity-Optimization of Local Demand Responsive Services	3.1.3	II	March 1979
Regional System Concept Development	3.1.4	II	Sept. 1979
Increased Productivity-Optimization of Peak Period Commuter Services	3.1.3	II	March 1980
Increased Productivity-Optimization of Line Haul/Integrated Services	3.1.3	II	March 1980
Criteria for Evaluating Private Industry Products			
Single Module	3.4.1	I	Nov. 1976
Pilot System	3.4.1	II	March 1979
Area Wide System	3.4.1	II	Dec. 1981
DESIGN METHODOLOGY			
Shared Ride Taxi Control System Design	3.2.1	I	June 1977
Pilot System Simulation Model	3.1.2	I	Oct. 1977
Pilot Area Wide System Guideline and Handbook	3.1.2	I	March 1978
Laboratory AWDRT Control System Simulation	3.4.3	I	April 1978
System Design Guideline & Handbook	3.2.2	II	June 1979
Micro Simulation Model	3.2.2	II	June 1980
System Optimization Simulations	3.1.3	II	Dec. 1980
Guidelines for Optimizing Design	3.1.3	II	Dec. 1980
Macro Simulation Model	3.2.2	II	June 1981
Regional System Design Criteria	3.2.3	II	Oct. 1981
COMPUTER SCHEDULING, DISPATCHING, & CONTROL SYSTEMS			
Pilot Subscription Bus Software	3.1.3	I	July 1977
75 Vehicle Pilot Integrated DAR/Fixed Route System Software	3.3.2	I	Jan. 1978
Pilot Shared Ride Taxi Software	3.3.1	I	March 1978
200 Vehicle Communication & Control System Software	3.3.3	II	Oct. 1981

TABLE 3

d. Regional system concept design and development

An in-depth cost/benefit analysis will be performed to determine to what extent the investment in AWDRT will be beneficial to the transit developers and users. The estimates of costs for system implementation, operation, maintenance, research, development and user charges will be evaluated in terms of the objectives of the AWDRT concept being implemented. Although preliminary analysis has shown that the concept of AWDRT is cost effective, it should be noted that most existing or proposed demand responsive systems provide important transportation services without the expectation of meeting the full costs through the user fare. Thus net economic benefits will accrue, through proper operation with other transit services, through the replacement of unprofitable routes or services, through increased capacity on all lines reducing or minimizing the costs of providing off peak services, etc. In addition, non-economic benefits will be identified such as increased mobility for various population groups, reduction in congestion and pollution, energy conservation, and reduction in crime with increase security. While costs for system implementation can be documented, this effort will address itself to the how and why each selected scheme should be implemented on a cost-benefit basis. The output of this analysis will be used to assist in decision making on the extent of AWDRT development.
Included in this program element will be an assessment of the potential impact of large regional areawide systems. This effort is a continuation of an initial assessment in progress under funding by the Office of R&D Policy (TST-10). Tools will be developed to determine the economic, service, vehicle and control system impacts of large urban areawide demand responsive transit systems. The potential increase in the modal split, from 2 to 5% at present, to 15 to 30% would have significant impact on energy, the environment, traffic congestion and transit economics. The analysis tools will be applied to data representative of several types of urban areas. The results will be validated and the analysis tools will be prepared for dissemination.

The task of Review and Assessment of Operational Experience will be performed through an analysis of past and current efforts in Dial-A-Ride and integrated services. Consolidation of the knowledge of the successes and failures of previous systems is essential to guide follow-on developments. This effort will produce guidelines in the form of a handbook for the development of pilot AWDRT systems such as typified by Orange County, Calif., Ann Arbor, Michigan and Rochester, N.Y. and will define analysis requirements for the critical data on the design, development, implementation and evaluation of other systems. The critical questions to be addressed in this and follow-on tasks (see para. 1.5.2) will be reviewed with industry representatives via a workshop.

In the review process, case studies conducted in cooperation with the Service and Methods Demonstration Program will report the results of local initiatives, and will provide data on technology used, implementation, funding, marketing and political techniques which were followed by states and localities. These case studies will be accomplished for both the successful and unsuccessful implementations and the results will be reflected in the guidelines to be developed.

Studies will be conducted to increase the productivity of integrated flexible route and fixed route services. The proper relationship between the flexible route and fixed route services will be established to cost effectively provide maximum system productivity. Included in the study will be measures of productivity, data requirements and techniques for estimating productivity. Procedures or policies limiting the productivity of demand responsive modes (such as 100% door stop service) will be identified and the effects quantified. Techniques for optimally scheduling subscription passengers will be developed as will methods for predicting the capacity of demand responsive services. Methods for overcoming current limitations on demand-responsive productivity will be developed and detailed simulation analyses will be conducted on the effects of implementing the methods. This effort will initially provide data to the transit operator for improving pilot systems in being and will provide design information for incorporation into the AWDRT Guideline Handbook and into methods and techniques for follow-on scheduling, dispatch and control system development. The techniques developed for subscription services will form the basis for follow-on subscription service software development.

The development of a regional concept for Demand Responsive Systems will depend on the results of the cost-benefit analysis and the extent to which control and communications systems can be effectively developed. The concept development and analysis is required prior to deployment of areawide techniques of integrating demand responsive and fixed route line haul service in regional urban transit systems of 1000 vehicles or more. The analysis will examine alternative configurations, flexible route and fixed route systems that provide optimum areawide service. The studies will assess the proper relationship between flexible route and fixed route transit systems that will most cost effectively meet the needs of the assumed scenario. Further, the analyses will: estimate demand, fleet sizes, capital costs, operating costs and revenues; define driver scheduling and fleet management requirements; define computer control and communications requirements as well as to identify the effects of integrating service and communication with rail modes. The concept if feasible, would be designed and developed in follow-on program elements.

1.5.2 System Design

This program element is aimed at developing guidelines and system designs based on work accomplished in the previous program element. This element consists of the following three tasks:

a. Shared Ride Taxi Control System Design

b. AWDRT Guideline Development

c. Regional Control System Design

The Shared Ride Taxi program element is directed at increasing the productivity of taxi operations through development of an automated scheduling and dispatch system. At present, taxis operate at very low productivities, providing on the average only 2 rides per hour. Under shared ride conditions, it is expected that this productivity could be improved by a factor of 2 to 5 into a range of 4 to 10 passengers per hour. This would make possible a considerable reduction in the cost of taxi services as compared to the single passenger operation. Successful taxi based demand responsive services operate in the United States, and the taxi industry has indicated strong interest in participating in the further development of this service. This concept presents an opportunity to develop a near term scheduling and dispatching system which can be implemented at an early stage for evaluation and provide a significant payoff for the R&D dollars invested. Technical requirements for the entire system will be developed including number of vehicles, size of service areas and demand rates. The design of the control system will be based on previous scheduling and dispatching algorithms developed for Dial-A-Ride concepts but modified for the shared ride taxi concept. Based on this design, the system will be developed and evaluated in follow-on program elements. Included in the design effort will be consideration of non-scheduling related areas such as driver commissions, fare calculations, and other institutional factors and operating practices which may affect the technology.

The AWDRT guideline development is based on the review and assessment of operational experience conducted in a previous program element. The intent of this effort is to develop the necessary analysis base for the implementation of areawide systems. The analysis results based on the extrapolation of historic data, current system experience, and simulation exercises will be collected and formatted in the form of a handbook to be made available to the transit industry. This handbook will contain procedures, guidelines, demand, cost, performance models, and data on how to design, develop, implement and evaluate areawide demand responsive systems. To support the development of this handbook, a large scale AWDRT simulation will be developed to systematically evaluate the service, cost, and reliability characteristics under a variety of urban conditions as anticipated for each application.

The Regional System Design will be based on the concept developed earlier in the program and will be performed only if the analysis indicates that such a system is both feasible and cost effective. The task output will include a service design, computer and communication requirements and design, a system development plan and will estimate performance and costs

1.5.3 Technology Development

The Technology Development program element is divided into the following areas:

- Shared Ride Taxi Control System
- Pilot System Software
- Communication and Control System
- Regional Control System

The shared ride taxi control development will be based on the system design described in Section 1.5.2 and will be built upon the previous system developed for pilot demonstrations and adapted to the requirements of the taxi concept. The development will consist of a baseline computer scheduling and dispatching system for use as a starting point for the private transit community. The software will be modularized to the highest extent possible to provide the transit industry with a wide variety of software options that can be tailored and refined to their individual requirements. Pilot tests of the developed system will be conducted and are described under section 1.5.4.

The Pilot System Software like the Shared Ride Taxi effort will be based on available software used in previous Dial-A-Ride efforts and the Rochester system in operation today, and will follow the guidelines described in Para. 1.5.1. This effort will optimize and expand the software from the current system size up to a system operating with 75 vehicles. The system will be developed for implementation on a small dedicated computer and will include computer scheduling and dispatching, digital communications, automated route and schedule data retrieval, and be capable of integration with line haul services. The software will be modularized such that the developments can be tested in more than one transit community either under UMTA's Service and Method Demonstration Program or by local initiative.

The Communication and Control System development will build on the Pilot System Software and also the development work of shared ride taxi. The previous systems will be expanded to handle up to 200 vehicles and the effort will develop and integrate the needed computer and communications technology. The development will include basic scheduling and dispatching capabilities, automatic processing of requests for trips by customers, advanced digital communications with drivers, integration of automatic vehicle monitoring (AVM) systems, and automatic route and schedule information retrieval. The communication and control system development will be tested and evaluated through selected operational pilot site tests as described in Section 1.5.4.

The Regional System development is based on the concept and design described in sections 1.5.1 and 1.5.2 and will be a long term effort to be accomplished after the successful completion of all program elements described in this paper. Since this advanced concept may only apply to a limited number of urban areas, plans for development and demonstration are not included in this paper. Should conditions warrant, plans will be developed in a follow-on program.

1.5.4 Dissemination and Evaluation

The Dissemination and Evaluation element of the program will be centered around the test and evaluation of all concepts developed in the program in specific pilot demonstration support and in the maintenance and dissemination to the transit community of all planning data, validated software and simulations. It should be stressed that the hardware, site specific software and operational costs of all pilot testing will be funded through the UMTA's Service and Methods Demonstration Program. In addition, the testing will be conducted as much as practical in conjunction with other related UMTA developmental programs such as Automatic

Vehicle Monitoring. The tasks of Dissemination and Evaluation are as follows:

- Evaluation of Industry Developed Products
- Specific Demonstration Support
- Software and Simulation Maintenance and Distribution

The Transportation Systems Center is developing criteria which will serve as benchmarks against which operational scheduling and dispatching systems can be measured for areawide demand responsive application. The criteria will be used by the transit agencies and industry and will be in the areas of functional capabilities, performance, cost and capacity. The TSC effort will address fleet sizes between 10 and 50 vehicles and the system evaluation will include system specific tests as required. The areawide demand responsive concept implies fleet sizes in excess of 50 vehicles and the follow-on activity will expand the basic criteria to address a large range of system sizes. The larger system criteria will be based in large measure on the guidelines described in section 1.5.2. It is anticipated that the actual evaluation will be a joint government/industry operation.

The Specific Demonstration Support will be in conjunction with Pilot Tests of each phase of the AWDRT which have been developed. Operational pilot sites will be selected by the government for the testing and will be in cooperation with local initiatives wishing to deploy the technology developed in the program. It is the intent that this effort will be limited to assistance to the local transit agency in adapting the AWDRT software to the site specific transit system. This demonstration support, in addition to supporting the local agencies will gather data on the system operation to validate the software and simulations previously developed. Included will be the development of a laboratory to support evaluation of a family of devices for data input and simulated communications links for exercising demand requests to a simulated AWDRT central control facilty.

The Software and Simulation Maintenance and Distribution effort will support the testing by providing for modification of the software as may be required by the site specific application and will maintain and document all developments for distribution to the transit community. This distribution will take the form of technology sharing and will consist of all products developed in the program. The products will be designed for wide application and for use by technical specialists within the transit community.

1.5.5 Program Support

The program support element includes the effort by the Transportation Systems Center (TSC) who has been designated as the systems manager of the System Design and System Development Program Elements. TSC will be responsible for all activities in these areas as well as supporting the program office as described in paragraph 6.0.

Independent technical studies will be conducted by the program office to evaluate novel technical approaches, to perform parametric trade-off analyses and to evaluate the impacts of the AWDRT system development.

1.6 Life Cycle Phasing

The AWDRT program is not directed towards the development of complete deployable systems, but rather towards critical system and subsystem elements which may be used in a variety of advanced transportation systems. The program elements identified in Section 1.5 will be initiated in FY-76. Life cycle phasing is not applicable to the AWDRT program since it is not intended to be a development program for a specific system.

2.0 PROGRAM FUNDING

The AWDRT Program will be a two phased program with the phases as described below.

> Phase I - This phase will include the detailed cost/benefit analyses as well as the analyses needed to support Phase II development. In addition, selected Technology Developments will be accomplished. These Technology Developments will be limited in Phase I to the extension of current system developments for deployment and evaluation in additional transit communities and the development of systems to support current

transit needs and in which an early payoff can be realized. Specifically, these Technology Developments will be limited to the development of the Pilot System Software and the Shared Ride Taxi Software. Phase I will require funding of $4375K.

Phase II- This phase will be based on the results of Phase I and will, if appropriate, include any additional developments. Activities anticipated for Phase II are described in this paper for completeness and to indicate the possible future program direction. However, the actual work, if any, to be performed in Phase II will not be determined until Phase I is completed.

3.0 AWDRT PROGRAM ACTIVITIES

Brief descriptions of each of the AWDRT program activities are included in the following paragraphs. The descriptions contain the objectives, program descriptions and deliverables for each of the program elements. A summary chart of the AWDRT program activities schedule is shown in Table 3.1.

The program activities were structured to meet the stated requirements and objectives set forth in Sections 1.2 and 1.3, and the desired outputs identified in Section 1.4.

3.1 Analysis and Assessments

3.1.1 AWDRT Cost Benefit Studies (Phase I)

A cost benefit analysis will be performed to assist in decision-making on the extent of AWDRT development and deployment. The analysis will assess the total system development, deployment and operational costs and evaluate these costs in terms of the net economic and non-economic benefits to be derived. In addition, this effort will assess the potential impact of large regional areawide systems. Different size local service modules with new combinations of demand-responsive and fixed route services will be considered. Alternative methods of handling increased line haul demand (e.g., shorter headways, more routes or higher capacity equipment) and associated overall system effects will be analyzed. The effects of substituting more fixed route for demand-responsive service

TABLE 3.1

AWDRT PROGRAM ELEMENT

AWDRT PROGRAM ELEMENT

4.1 ANALYSIS & ASSESSMENT

- 4.1.1 Cost Benefit Analysis
  Large Region Impact Analysis
- 4.1.2 Review & Assessment of Operational Experience
- 4.1.3 Increased Productivity
- 4.1.4 Regional System Concept Development

4.2 AWDRT SYSTEM DESIGN

- 4.2.1 Shared-Ride Taxi Design
- 4.2.2 System Design Guideline Development
- 4.2.3 Regional System Design

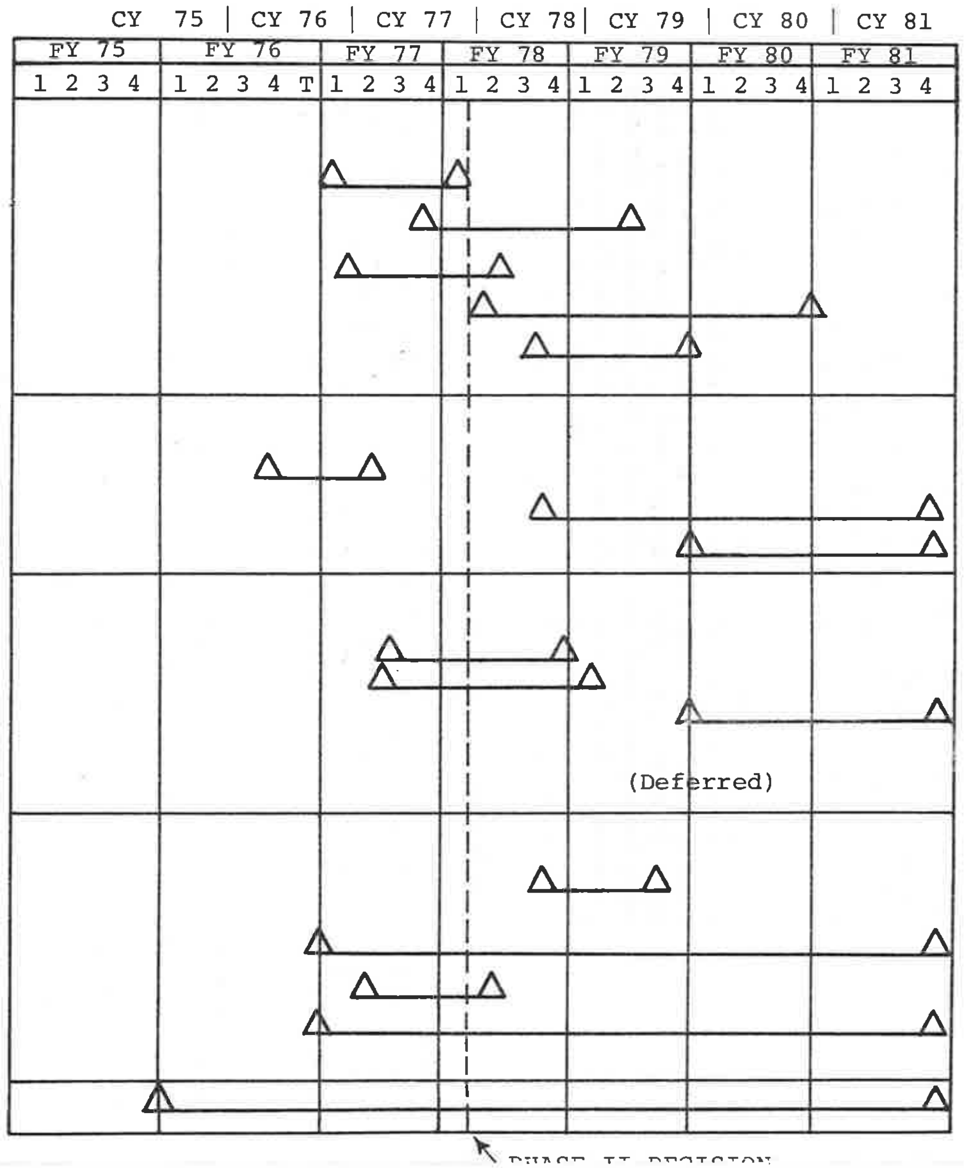
4.3 AWDRT TECHNOLOGY DEVELOPMENT

- 4.3.1 Shared-Ride Taxi System
- 4.3.2 Pilot System Software
- 4.3.3 Communication & Control System Development
- 4.3.4 Regional Control System Development

4.4 DISSEMINATION & EVALUATION

- 4.4.1 Evaluation of Industry Products
- 4.4.2 Specific Demonstration Support
- 4.4.3 Laboratory Development
- 4.4.4 Software & Simulation Maintenance & Distrib.

4.5 PROGRAM SUPPORT



on the elderly and handicapped will be assessed. The reports which will be generated will assess whether better service at a lower cost can be achieved through AWDRT and will be a critical input to assist in building design tools in the AWDRT Guideline development and for decision-making on program direction.

3.1.2 Review and Assessment of Operational Experience (Phase I)

This effort will gather and analyze data on current areawide transit plans and applications to develop requirements for an AWDRT handbook. Based on preliminary scenarios as defined in the cost/benefit analysis task and the questions to be addressed in the handbook, the review and assessment effort will define data requirements, gather and assess the utility of historic data, and define analysis requirements. The output of this task will be pilot system guidelines, detailed handbook requirements, specification of analysis requirements, functional specification of micro and macro level models, and initial simulation development.

3.1.3 Increased Productivity Studies (Phase II)

While guidelines and control procedures will be developed for integrated fixed-route and demand responsive service for AWDRT systems, a further tailoring of service to unique local conditions could greatly increase capacity and productivity. Alternative operating strategies will be developed to improve productivity for local, short-distance, flexibly routed services; commuter and other peak period services; line haul and other off-peak long-distance urban service.

Local services will be optimized by the development, simulation and small in-service tests of operating strategies combining the best features of Dial-A-Ride and fixed route. Techniques to be assessed include route and point deviation in which vehicles are prescheduled at high activity locations such as shopping centers but with time allowed between scheduled stops for deviation to door stops, particularly for the elderly and handicapped, or to nearby street corners.

Commuter and other peak period service optimization will focus on determining the extent to which subscription bus services should supplant or supplement conventional fixed-route services. Methods of analyzing the expected cost, fleet requirement and performance of alternative placements of subscription services will be developed; an assessment of the cost and service impacts of substantially replacing fixed-route commuter services with subscription services will assist in determining the optimum mix of subscription and conventional services; and computer software will be developed to optimize the scheduling of subscription vehicles and drivers, day-to-day adaptability in scheduling, and for management operations.

Line haul and longer off-peak trip service optimization will focus on determining the best mix of conventional fixed-route services, flexibly routed or scheduled services and integrated local and line haul services. Under low demand line haul services experience low productivity and potentially can be improved by more flexible services. Additionally, local travel patterns can be expected to exist in which the best service consists of having the small bus used for local collection of passengers proceed non-stop to a distant destination. Simulations will be used to refine the expected costs, performance and other characteristics of such services. Local conditions indicative of the success of special line haul services will be defined and the impacts on transit institutions and control systems assessed.

The output from these tasks will provide critical data for the development of guidelines and for the design of the critical automation elements of AWDRT. The software and simulations which will be developed will be validated through pilot projects initiated by local transit agencies and funded by the UMTA Service and Methods Demonstration Program.

3.1.4 Regional System Concept Development (Phase II)

While it is clear that the AWDRT concepts are applicable to larger areas (e.g., Metropolitan Washington D.C. and Los Angeles) the size and complexity of such applications require additional concept development before design, development and deployment begin.

The effects of longer trips and more dispersed origin/destinations on system configuration and performance will be addressed. Methods of partitioning the fleet, computers and communications will be assessed and approaches to interfacing the results identified. Estimates of the costs and performance levels will be developed, initial tests conducted, R&D requirements identified, funding levels estimated and an R&D program plan developed. The results of this effort will include a preliminary service design, performance and cost estimates, computer and communications requirements and design, and a system development plan.

3.2 AWDRT System Design

3.2.1 Shared Ride Taxi Control System Design (Phase I)

Shared ride taxi operations offer the potential of being an integral part of areawide systems although improvements are needed in the service and management operation to increase productivity. The improvements needed coincide with the taxi industry request for support in the control system development. It has been estimated that productivity improvements by a factor of up to 5 could be achieved but would require a sophisticated scheduling and dispatching system to achieve this capability. This task will be to design a pilot test computer scheduling and dispatch techniques and communications system for shared ride taxi with and without AVM.

3.2.2 System Design Guideline Development (Phase II)

This effort will develop the guidelines for the design, development, implementation, and evaluation of areawide demand responsive transit systems. Included in the guidelines development will be the development of simulation tools to supplement those described in 3.1.2 and 3.1.3 to be used to evaluate scheduling algorithms and control procedures for areawide demand responsive transit systems. Both the micro and macro models will be fully developed, validated and documented to simulate vehicles, fleets, services, and demand for a variety of fixed route and demand responsive service alternatives over a broad spectrum of area configurations. The simulation will also be used to support advanced studies such as Regional System Design. The results of this effort will be a handbook for transit agencies for AWDRT guidance containing comprehensive guidelines; models to estimate demand, cost; performance evaluation tools; and a simulation capability to support other program analysis tasks.

3.2.3 Regional Control System Design (Phase II)

This task will be based on the concept developed in the program element described in paragraph 3.1.4. The design will be in accordance with the R&D program plan which was developed and will be performed only if the analysis indicates that the system is both feasible and cost effective and that a potential pilot demonstration can be identified where a system of this size is needed. The system design will include software design for the complete integration of the flexible route paratransit elements and the fixed route conventional transit in which both systems would be operating in a full cooperation mode. Simulations will be developed to supplement those developed in the AWDRT Guidelines to evaluate the design in detail. The task results will be a integrated design for future development and evaluation.

3.3 AWDRT Technology Development

3.3.1 Shared Ride Taxi Control System (Phase I)

An automated scheduling and dispatching shared ride taxi control system will be developed under this task. The software will be developed in a modular manner using techniques that insure broad application. The software functions will include request recording and management of queues, monitoring of vehicle routes, tours, and current positions through AVM or operator input, execution of the scheduling function, fare development, and recording of events for management information and strategy planning. The developed system will contain the capability of operating with and without digital communications and automatic vehicle monitoring. The program output will be tested as described in paragraph 3.4.2:

3.3.2 Pilot System Software (Phase I)

Software will be developed for implementation in pilot AWDRT systems that will be used for demonstration and evaluation of system sizes of up to 75 vehicles. This software will be developed along the guidelines described in paragraph 3.1.2 and will be an expanded and refined version of software developed for the Rochester Demonstration. The system will include the scheduling and dispatching software, route and trip processing software, digital communications with drivers, and traffic management functions. Included will be software for pilot subscription bus services. The software processes will be modularized and independent to the extent practical to provide the transit industry with a variety of pilot software options that can be tailored and refined to a number of community requirements. The output of this task will be operational software for use on small computers with complete documentation for an integrated demand responsive system for pilot system sizes up to 75 vehicles and for subscription bus. Included also will be documentation of the functional requirements, overall system design and the detailed specification of the hardware and software components. Testing of the software will be as described in paragraph 3.4.2.

3.3.3 Communication and Control System Development (Phase II)

A baseline control system for systems capable of supporting 200 vehicle demand responsive fleets fully integrated with fixed route service and expandable to larger fleets will be developed in this task. The system will utilize the guidelines developed in Task 3.2.2 and will be built on previous pilot system software and the shared ride taxi effort. It will be designed to support the complete operational computer requirements for areawide transit systems, to reduce the need for multiple computers and to improve transit operations via access to computer based operating data. This system will include the basic scheduling and dispatching capabilities developed for smaller systems, automatic processing of requests for trips by customers, advanced digital communications with drivers, integration of automatic vehicle monitoring (AVM) systems, automatic route generation and the integration of other traffic management functions.

This project is characterized by two significant attributes, namely the design and integration of several technologies (e.g. AVM, digital communications) for a large (200 vehicle) demand responsive fleet and the development of an integrated operational software system that can both exploit these latest technologies and perform the required operational functions in a modular fashion. The design will be such that a family of system capabilities can be evaluated depending on site-specific requirements. The project results will be the development of specifications, computer and communications requirements, overall system design, operational computer software, acceptance tests and documentation.

3.3.4 Regional Control System Development (Deferred)

The Regional Control System Development task will be deferred to follow-on activity and the future completion of the task will depend on cost benefit analysis and a specific pilot site requirement.

3.4 Dissemination and Evaluation

3.4.1 Evaluation of Industry Developed Products (Phase II)

TSC is in the process of preparing criteria for standards for assessing control systems developed by industry for AWDRT. This criteria will serve as benchmarks against which operational scheduling and dispatching systems can be measured. The TSC effort is limited to system sizes of 10-50 vehicles and this program element will address systems in a range of sizes up to 75 vehicle systems. This task will build on the TSC effort and will be based on data developed in the AWDRT Guideline Handbook. Included in this task will be a validation on a specific system of the criteria developed.

Follow-on evaluation of industry developed products will be a joint industry government effort.

3.4.2 Specific Demonstration Support (Phase I & Phase II)

Pilot tests will be conducted on each program element which has been developed. Operational pilot sites will be selected by the government and the tests will be conducted in conjunction with demonstration grants funded under the UMTA Service and Methods Demonstration Program.

Multiple contractual efforts will be conducted in support of this task depending on the number of sites supported. These efforts will be in support of specific projects and the tests to be conducted will be in cooperation with local initiatives wishing to deploy the technology developed in this program. This demonstration support will take the form of assisting the local transit agency in the planning and development of the system to be deployed. Specifically, advice and assistance will be provided to the local agency in tailoring the modularized software developed in this program to the site specific requirements. In addition, this task will provide for the evaluation of the deployed system and recommendation of changes for follow-on systems.

3.4.3 Laboratory Development (Phase I)

This project will provide for the development of a laboratory facility at TSC for evaluation of hardware and software components prior to the integration of these components in an AWDRT system design. The laboratory facility will include a simulated AWDRT control facility, a family of input devices for evaluating data input by the operators, and simulated communications links providing the capability for exercising service requests. The overall output of this effort will be evaluation reports, recommended changes to current software and special purpose product development.

3.4.4 Software and Simulation Maintenance and Distribution (Phase I & Phase II)

The operational program products identified in the system development elements and the simulation capabilities developed in the system design elements will require proper maintenance and documentation for distribution. Each software product as it evolves through development, field testing, and final operation will undergo numerous revisions. This task will maintain the software by making all necessary changes and keep the level of documentation current. These programs as developed will be tested extensively by the contractor of this activity to minimize corrections. In addition to the maintenance and documentation efforts this task will provide for the dissemination of the software products and any related documentation. The dissemination will be passive employing such methods as workshops and seminars. On request assistance will be provided to prospective users to facilitate software implementation. Then this task will provide for the maintenance, documentation, and distribution of the software development efforts as described in Section 6.4.

3.5 Program Support (Phase I & Phase II)

Support to the program is composed of TSC support to the Program Office and procurements for Technical Support and Independent Studies.

TSC Support

The TSC support to this program will be as described in paragraph 6.0.

Technical Support and Independent Studies

A number of studies, reviews, and technical assessments will be performed to determine the merits and to gain to determine the merits and to gain insight into the critical technical issues. Some activities will require extensive studies to be performed, while others can be resolved by the method of consultation with knowledgeable experts in the technical field of concern. The results of these activities will be comprehensive reports and assessments of the potential improvements in the state-of-the-art and related technologies, of plans of private industry, and a catalog of available technology for use in areawide transit and criteria for the assessment of privately developed products.

4.0 Prior and Related Efforts

The following are past and on-going activities that have and will continue to provide the knowledge base for the AWDRT program.

4.1 CARS Project

The early Federal involvement in demand-responsive transit started with the Computer Aided Routing System Development, project CARS, at the Massachusetts Institute of Technology in 1967. While the CARS project provided basic concept development in demand responsive systems, it indicated a need for further development in the definition of service patterns, algorithms for computer scheduling of customers and extensive simulation and analysis prior to actual deployment.

4.2 Dial-A-Ride Demonstrations

Following the CARS project UMTA began a series of demonstrations and experiments to test Dial-A-Ride concepts in actual operation. These include special services for the elderly and handicapped in Cranston, Rhode Island and St. Petersburg, Florida and for the poor and unemployed in the Watts area of Los Angeles. These demonstrations and experiments provided operating data and yielded experience on practical problems of service implementation.

4.3 Haddonfield Project

The largest federally sponsored local Dial-A-Ride was conducted in Haddonfield, New Jersey as an UMTA funded R&D project. This project provided a substantial amount of experience in the operation of Dial-A-Ride services in a suburban setting; specifically it provided a source of data on demand, cost, performance and computer control technique.

Several conclusions regarding the computer system design were reached as a result of the Haddonfield experience:

1. computer scheduled service can be expected to be better than manual service, even with small fleets;

2. computer scheduling techniques need to be extended to include a variety of passenger classes and transfers to fixed route vehicles:

3. mixed computer-manual scheduling is worse than either alone (the computer needs complete accurate information on passengers and vehicles to be effective);

4. the computer must have a complete, easily used set of scheduling, dispatching, customer information and fleet status commands and functions and

5. scheduling techniques that rely on constrained limitations on customer pickup and delivery times result in low productivity and poor service.

The system provided excellent service, was heavily used but was discontinued in March 1975 when federal funding ended.

The experience highlighted a typical problem that can occur when funding arrangements for new types of service are not in concert with existing transit institutions.

4.4 Rochester

The Service and Methods Demonstration Program is currently funding a demonstration in Rochester, New York of the integration of Dial-A-Ride with fixed route services. As a part of this demonstration, Rochester is using computer scheduling and dispatching designs tested in the previously described Haddonfield projects and improved under a University Research grant to MIT. The services being provided are part of Rochester's overall plan to evolve from an exclusively fixed route system to a mix of flexibly routed small vehicles and fixed route lines providing areawide coverage.

The Office of Research and Development is supporting the demonstration by managing the development of computer software for scheduling and dispatching Dial-A-Ride vehicles. The advent of the demonstration offered a unique opportunity to expand on Haddonfield experience with the Dial-A-Ride computer. The transferable version of the Haddonfield software was incorporated into and is being expanded in the demonstration. The tested version of this software is being prepared for public release and the Rochester result will be used in developing implementation guidelines and computer software for AWDRT.

4.5 Local Initiative Dial-A-Ride Installations

In addition to Federal government initiatives, local governments in the U.S. had initiated (as of June, 1974) 42 DAR installations which were either in service or scheduled to begin service before the end of that year. Many small systems have since been added.

Typically, these installations are small systems either to serve a limited market (e.g. the elderly) or to introduce DAR into an area on a small scale. For example, 40 of the 42 installations have less than 15 vehicles and serve an average population of about 26,000. By and large, most of these small systems have been successful and hence, have demonstrated the ability of DAR to provide economically acceptable service in areas of low ridership. Those which have been discontinued such as in Richmond, California and Fairfax, Virginia highlighted the need for the availability of better planning data, the tools to realistically estimate demand, cost and fleet size and the coordination necessary to integrate the local DAR and fixed routes services.

An initiative by Santa Clara County to implement an areawide system consisting of 90 vehicles, serving one million people in 18 service areas, has also highlighted several critical problems that need further development. Again, the problems lie in the areas of planning and design tools needed to obtain better estimates of demand, fleet size, and level of service required, as well as simulation tools for evaluation of various approaches and the lack of guidelines available to operators prior to its field implementation.

4.6 Shared-Ride Taxi Studies

In parallel with the Haddonfield Project, the University of Tennessee, under UMTA funding, investigated private shared-ride taxi operations in Davenport, Iowa and Hicksville, New York. These taxi systems carried 900 to 1300 passengers per day in general competition with other transit services. The information developed is basically important to the design of shared-ride taxi control systems.

4.7 Relation to Other DOT Programs

The AWDRT Program will be closely coordinated with the Service and Methods Demonstration Program. The Service and Methods Demonstration Program provides fundings for initial deployment of innovative transit services and will provide a field laboratory to test and evaluate many of the outputs of this program. A complementary project which will also provide input to the AWDRT program is the Paratransit Requirements Study carried out by the Office of Research and Development in UMTA.

The High Modal Split Study sponsored by the Office of R&D Policy of the Office of the Secretary provides preliminary findings to the AWDRT program which will conduct a much more detail assessment of the impact of high modal splits in large regional areawide systems.

5.0 Identification of Risks

There are no schedule risks associated with the AWDRT development program since it is not intended to develop a specific system, but is intended to develop the critical technologies and techniques required for a spectrum of demand responsive systems. The technical risks in the development of critical technologies are varied. In some of the program elements the technical risks are low, in others the risks are related to the expectation of obtaining the full desired technical outputs. The cost risks of the entire AWDRT program are reasonable and sufficiently bounded since the cost of one program element is largely independent of another, and the entire program is made up of a number of relatively controllable elements. Also, reviews and decision points are periodically scheduled throughout the AWDRT development program to provide the reassessments of the AWDRT objectives and the extent to which the program elements meet these objectives, or whether changes in the scope or direction of the program elements are required.

6.0 Responsibilities

The UMTA Office of Research and Development, Bus and Para Transit Technology Division (URD-20), will have overall responsibility and financial control of the program. The UMTA Program Manager (URD-22) for the Areawide Demand Response Transportation Program (AWDRT) will be responsible for policy, overall program management, technical direction and task coordination. The UMTA Program Manager will be supported by the program office as indicated in Figure 6.1.

The Transportation Systems Center (TSC) has been designated Systems Manager of the System Design and System Development Program elements. TSC will be responsible for all the activities in these areas and, in addition, will be responsible for the dissemination and maintenance of the AWDRT program output.

The Analysis and Assessment and the Dissemination and Evaluation elements will be the responsibility of URD-22 which will also serve as systems manager for these activities. TSC will provide support as required to these programs.

The detailed activities and tasks that support the operations of the program office for AWDRT are as follows:

6.1 Program Office Support-(TSC)

The Transportation Systems Center (TSC) will support the program office and will:

(a) assist in the preparation of internal DOT documents, such as planning documents and Request for Proposals (RFP);

(b) assist in the evaluation of technical proposals;

(c) assist in the preparation of and the presentation of technical and management briefings;

(d) assist in the maintenance and planning of schedules and budgets; and

(e) assist in the coordination of AWDRT program activities with other on-going or planned related programs.

6.2 System Manager for System Design and Technology Development - TSC

TSC will support the UMTA program office acting as the System Manager for the Systems Design and Technology Development Program elements and will

(a) be responsible for all activities within these program elements

(b) issue contracts for the performance of program activities within this program element

(c) monitor and evaluate the performance of these contractors with respect to schedule, deliverables and quality of outputs

(d) provide technical program reviews to UMTA and

(e) coordinate all technical reviews including those given by contractors

6.3 Contract Monitoring-TSC

In addition to serving as System Manager for the System Design and System Development Program Elements, TSC will also support the UMTA program office in other program elements and will

(a) monitor and evaluate the performance of the contractors, with respect to schedule and deliverables for the AWDRT task elements assigned to TSC for technical monitoring

(b) assist in the technical program reviews and briefings and

(c) coordinate contractor documentation submittals with the technical review activities

6.4 Guideline Application Support-TSC

TSC will support this function of the program office and will

(a) assemble the technical knowledge obtained from the AWDRT Program and disseminate such information to the transit community through publication of annual reports or conducting technical workshops, as required

(b) serve as depository of computer softwares, models and simulation tools developed within the AWDRT program and assist the transit community on the application of these tools

(c) evaluate by the use of analysis, or computer simulations, the performance, cost, fleet size of proposed AWDRT systems submitted by UMTA program manager for review

(d) assess the procedures and system designs developed under the AWDRT program and propose changes as may be required to maintain an effective AWDRT Program.

6.5 Related Technical Studies and Developments-UMTA

The AWDRT program office will be supported by other on-going and planned R&D studies and developments, such as

(a) the Automatic Vehicle Monitoring Development Program

(b) the Paratransit Requirement Analysis Program

(c) the Service and Methods Demonstration Program, and

(d) the Assessment of Local Initiatives in Demand Responsive Transit Systems