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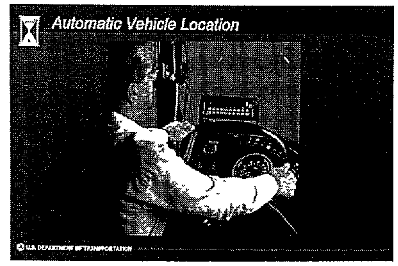
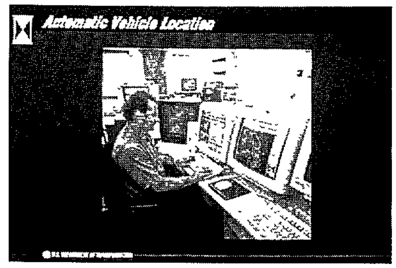


Benefits Assessment of Advanced Public Transportation Systems



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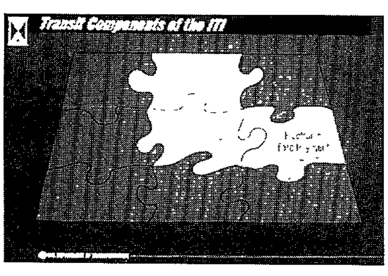

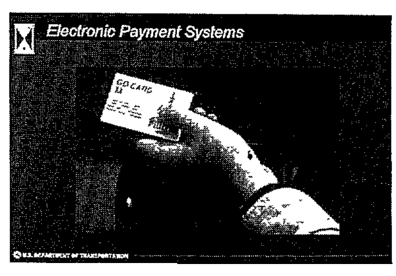

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Benefits Assessment of
Advanced Public Transportation Systems (APTS)

July 30,1996

Prepared for:

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U.S. Department of Transportation

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This report documents work performed under FTA's Advanced Public Transportation Systems (APTS) Program, a program structured to undertake research and development of innovative applications of advanced navigation, information, and communication technologies that most benefits public transportation.

This report presents the results of an analysis conducted by the Volpe Center, for the FTA, to provide and "order-of-magnitude" estimate of the expected benefits to the transit industry with the application of APTS technologies. Specifically, the study identified and quantified the major benefits derived from current applications of APTS technologies within the transit industry and projected current APTS benefits to a national level based on forecasts and reasonable assumptions on the potential future applications of such technologies within the transit industry.

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Table of Contents

List of Tables

List of Figures

LIST OF ACRONYMS AND ABBREVIATIONS USED IN THIS REPORT

AATA	Ann Arbor Transportation Authority (Michigan)
AC Transit	Alameda-Contra Costa Transit (Oakland, California)
ADA	American with Disabilities Act
APC	Automatic Passenger Counters
APTS	Advanced Public Transportation Systems
ATIS	Automated Traveler Information Systems
AVL	Automatic Vehicle Location
AVM	Automatic Vehicle Monitoring
BART	Bay Area Rapid Transit District (Oakland, California)
CAD	Computer-Aided Dispatch
Caltrans	California Department of Transportation
DRT	Demand Responsive Transit
FTA	Federal Transit Administration
GPS	Global Positioning System
IC	Integrated Circuit
ITS	Intelligent Transportation Systems
JPO	Joint Project Office
KCATA	Kansas City Area Transportation Authority
LACMTA	Los Angeles County Metropolitan Transit Authority
MARTA	Metropolitan Atlanta Rapid Transit Authority
MTA	Mass Transit Administration (Maryland MTA)
MTA	Metropolitan Transportation Authority (New York City)
Muni	San Francisco Municipal Railway (Muni)
NJT	New Jersey Transit
NYCT	New York City Transit
OMB	Office of Management and Budget
PTI	Public Technology Inc.
RF	Radio Frequency
SOA	State-of-Art
SOV	Single Occupancy Vehicle
TRB	Transportation Research Board
Volpe Center	Volpe National Transportation Systems Center
WMATA	Washington Metropolitan Area Transit Authority
WSTA	Winston-Salem Transit Authority

EXECUTIVE SUMMARY

Background

The Federal Transit Administration's (FTA) Advanced Public Transportation Systems (APTS) Program is a major element of the U.S. Department of Transportation's initiative in Intelligent Transportation Systems (ITS).

The APTS Program involves the application and integration of technologies in the following areas:

- Transit Management Systems
- Automated Traveler Information Systems (ATIS)
- Electronic Fare Payment Systems
- Transportation Demand Management

Study Objectives

This paper documents the results of an analysis conducted by the Volpe Center, for the Federal Transit Administration, to provide an 'order-of-magnitude' estimate of the expected benefits to the transit industry with the application of APTS technologies. Specifically, the following objectives were established for this study:

- Identify and quantify the major benefits derived from current applications of APTS technologies within the transit industry
- Project current APTS benefits to a national level based on forecasts and reasonable assumptions on the potential future applications of such technologies within the transit industry.

Study Scope and Approach

The study addressed four major APTS program areas with applications in the motorbus, demand responsive transit, and rail transit industries.

APTS Program Areas Considered

APTS Program Areas	Motorbus	Demand Responsive	Rail
Transit Management Systems	✓	✓	not considered
Automated Traveler Information Systems	✓	✓	✓
Electronic Fare Payment Systems	✓	✓	✓
Demand Responsive CAD*	n/a	✓	n/a

*CAD is computer-aid dispatching

The study was structured to address the current and projected deployments of APTS technologies, based on recent surveys and analyses conducted by the Volpe Center. A ten-year period (1996-2005) was chosen as the overall timeframe of the analysis with current and projected APTS applications characterized as being operational, under implementation (applications that are expected to be deployed in the transit industry over the next 2-3 years), or planned (applications that are expected to be deployed over the next 4-5 years).

The study considered the deployment of APTS technologies over a total of 200 motorbus, 212 demand-responsive transit, 16 light-rail and 14 heavy-rail transit systems. For each of these systems, data representing the current (1993) financial, operating, and performance characteristics (as reported by these transit systems under Section 15) was used to develop benefit estimating relationships of current and projected APTS deployments. Because of the nature of the reported benefits from current applications and the uncertainty in the quantification of these benefits, a range of estimates (low and high) was established on the projected level of benefits.

Summary of Benefits

The study identified a total of 265 APTS system deployments that are currently operational, under implementation, or planned for implementation over the next 10 years.

The projected total benefits of these deployments are estimated to range from $3.8 billion (low estimate) to as high as $7.4 billion (high estimate). These benefits are expressed in current (1996) discounted, present-value dollars. On an annualized basis, the annual APTS system benefits, over the next 10 years, from these deployments are projected to range from $546.6 million (low estimate) to as high as $1 .1 million (high estimate). From the projected total APTS benefits, approximately 44% of the total benefits are accrued from transit management system deployments, 34% from electronic fare pavement system applications, 21% from automated traveler information system deployments, with the remaining 1% from DRT-CAD system applications.

Total APTS System Benefits

	Transit Management Systems	Traveler Information Systems	Electronic Fare Payment Systems	Transit DRT- CAD Systems	Total
APTS Deployments (considered)	73	72	43	77	265
Benefits (Low Estimate) (in millions of discounted, present-value dollars)					
Total Benefits	**$1718**	**$796.0**	**$3,839.3**	**$44.7**	
Annualized	**$244.7**	**$113.3**	**$182.2**	**$6.4**	**$546.6**
Benefits (High Estimate) (in millions of discounted, present-value dollars)					
Total Benefits	$3,204.2	$1,592.0	$2 559.7	$74.5	$7 430.4
Annualized	$456.2	$226.7	$364.4	$10.6	$1,057.9

1.0 Background

The Federal Transit Administration's Advanced Public Transportation Systems (APTS) Program is a major element of the U.S. Department of Transportation's initiative in Intelligent Transportation Systems (ITS). Through the APTS Program, the Federal Transit Administration is making substantial investments in the deployment and evaluation of advanced technologies to improve the convenience, reliability, and safety of public transportation services.

The APTS Program involves the application and integration of technologies in the following areas:

- Transit Management Systems - integrate fleet based communication, Automatic Passenger Counting (APC), vehicle monitoring/location, and Computer Aided Dispatching (CAD) and control technologies to improve the overall planning, scheduling, and operations of transit systems.
- ***Automated Traveler Information Systems (ATIS)*** - includes a broad range of advanced computer and communication technologies designed to provide transit riders real-time information to make better informed decisions regarding their mode of travel, planned routes, and travel times. ATIS systems include in-vehicle annunciators/displays, terminal or wayside based information centers, kiosks, telephone information systems, cable and interactive TV, and the Internet.
- ***Electronic Fare Pavement Systems*** - are those advanced fare collection and fare media technologies, designed to make fare payment more convenient for transit users and fare collection more efficient and more flexible for the transit provider. These systems include fare media, ranging from magnetic strip to smart cards, and their associated fare collection and processing systems.
- ***Transportation Demand Management-*** are those applications that would combine technologies and strategies to promote the use of existing transportation infrastructure to serve the increased demand for transit. These applications would include computerized demand responsive transit reservation and dispatching systems, strategies to promote ride sharing, and coordinated transportation services among transit and non-transit providers.

2.0 Study Objective

This paper documents the results of an analysis conducted by the Volpe Center, for the Federal Transit Administration, to provide an 'order-of-magnitude' estimate of the expected benefits to the transit industry with the application of Advanced Public Transportation System technologies. Specifically, the following objectives were established for this study:

- Identify and quantify the major benefits derived from current applications of APTS technologies within the transit industry.

- Project current APTS benefits to a national level based on forecast and reasonable assumptions on the potential future applications of such technologies within the transit industry.

3.0 Study Scope and Approach

The study address four majority APTS program areas, shown in Table 1, with applications in the motorbus, demand responsive transit, and rail transit industries.

Table 1: APTS Program Areas Considered

APTS Program Areas	Motorbus	Demand Responsive	Rail
Transit Management Systems	✓	✓	not considered
Atuomated Traveler Information Systems	✓	✓	✓
Electronic Fare Payment Systems	✓	✓	✓
Demand Responsive CAD*	n/a	✓	n/a
* CAD is computer-aided dispatching			

This study built upon prior work, performed by the Volpe Center and other agencies, for the Federal Transit Administration under the APTS program. The overall study approach, depicted in Figure 1, consisted of the following steps:

- Available studies and surveys of APTS technology applications were reviewed to identify the major deployments and benefits derived.
- In those areas where benefits were identified, cited benefits were correlated to the type and class of APTS application.
- Using the cited benefit areas, estimating relationships were developed to quantify APTS benefits based on available transit data. For this analysis, the most recent data (1993) on transit system characteristics, reported under the FTA' s Section 15 program, was used.
- APTS benefits were projected to a national level based on a projection of future transit deployments of APTS technologies. Because of the nature of the reported benefits from current applications and the uncertainty in the quantification of these benefits, a range of estimates (low and high) was established on the projected level of benefits.

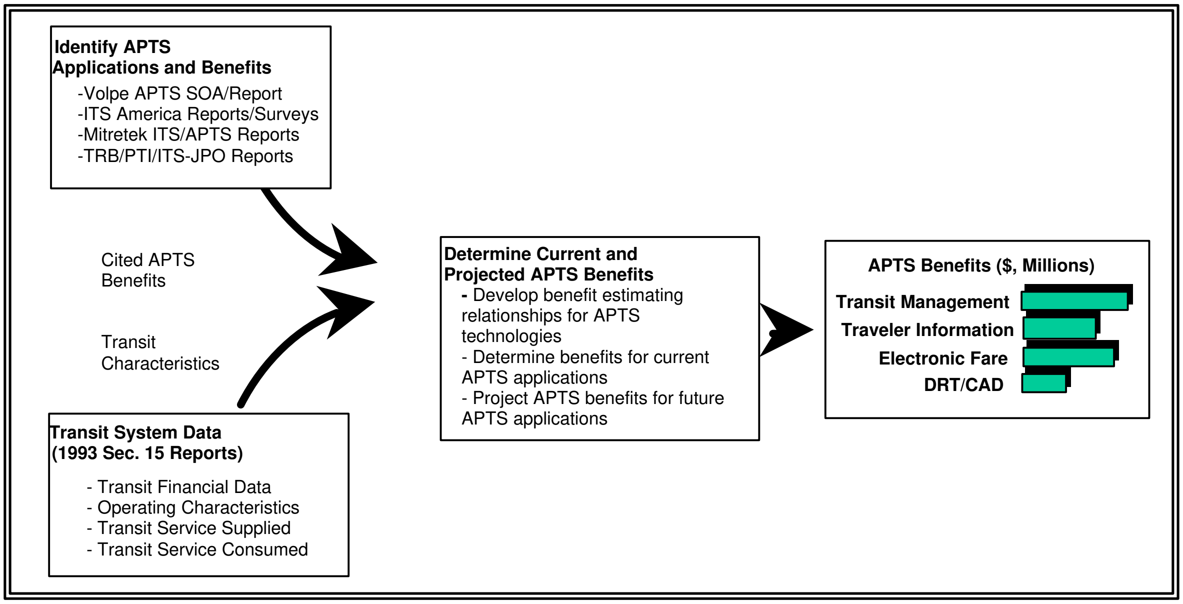

Figure 1 Study Approach

4.0 Analysis Data and Assumptions

The study was structured to address the current and projected deployments of APTS technologies, based on recent surveys and analyses,[1] conducted by Volpe Center. A ten-year period (1996-2006) was chosen as the overall timeframe of the analysis, as shown in Figure 2, with current and projected PATS applications being characterized as falling within one of the three following timeframes:

- ***Operational APTS Systems*** – representing currently deployed APTS technologies within the transit industry, the benefits are accrued over the entire ten years of the analysis period.
- ***APTS Systems Under Implementation*** – representing APTS applications that are expected to be deployed in the transit industry over the next 2-3 years, the benefits are accrued over an 8 year period (1998-2005) under the analysis.
- ***Planned APTS Systems*** – representing those APTS applications that are expected to be deployed over the next 4-5 years, the benefits are accrued over a 6 year period (200-2005) under the analysis.

1’ Advanced Public Transportation Systems: The State of the Art – Update ‘ 96’ The Volpe Center, U.S. Department of Transportation; January, 1996.
‘ Advanced Public Transportation Systems: APTS Deployments in the U.S.’ Preliminary Draft Report; The Volpe Center, U.S. Department of Transportation; January, 1996.

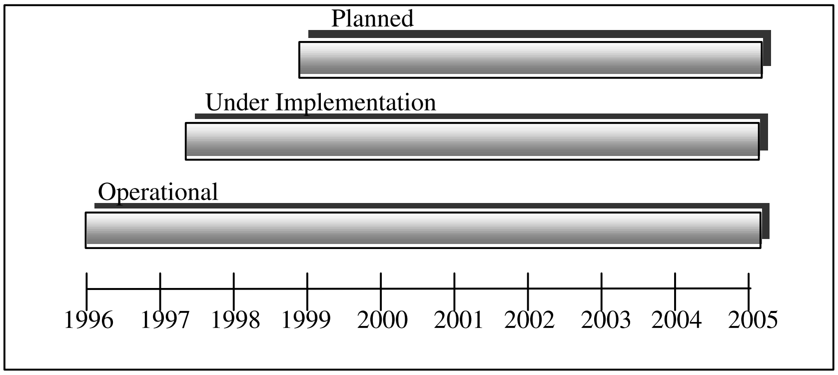

Figure 2 Analysis Timeframe for APTS Deployment

The study considered the deployment of APTS technologies over the total of 200 motobus, 212 demand-responsive transit, 16 light-rail and 14 heavy-rail transit systems (see Table 2). As shown, this analysis considered 43% of total motorbus transit systems (89% of the total motorbus fleet) and over 48% of the demand-responsive transit systems (90% of the total demand-responsive fleet) of the transit industry.[2] All of the U.S. heavy-rail and light-rail transit systems were considered. Appendix A presents a listing of all the motobus, demand responsive transit, and rail systems considered in the analysis.

Table 2 Transit Systems Considered in Analysis

	Systems Considered in Analysis		Total Transit Industry	
	# Transit Systems	# Vehicles	#Transit Systems	#Vehicles
Motobus	200	39,334	470	44,041
Demand Responsive	212	10.16	438	11.262
Heavy Rail	14	8,187	14	8,187
Light Rail	16	770	16	770

For each of these systems, data representing the current (1993) financial, operating, and performance characteristics were established based on the information reported by these transit systems under Section 15. A summary of the types of information available and used in this analysis appears in Appendix B of this report.

The primary assumptions used in this analysis were:

- The analysis considered a ten-year time horizon (1996-2005) for the deployment of APTS system technologies.

2 ‘ National Transit Database 1993 Section 15 Report Year,’ Federal Transit Administration, U.S. Department of Transportation, May 1995. Table reflects the total count of motorbus, demand-responsive and rail trnsit systems reporting under the FTA 1993 Section 15 reporting system. The number of vehicles represents total vehicle fleet operated in maximum service

- All benefits are calculated in current-year (1996) dollars and reported in total or annualized discounted present-value (1996) dollars.
- Office of Management and Budget (OMB) guidelines[3] and recommended discount rate of 7.0% were used in the calculation of all present-value dollar benefits.
- Transit ridership (as measured by unlinked passenger trips) was assumed to remain constant over the next ten years. Recent national trends[4] actually show a 5.0% decline in transit ridership over the past five years (or an average annual decline of 1 .0%) for all transit modes.
- Transit operating costs were assumed to increase at an average annual rate of 2.5%, over the next ten years. This reflects the national trend in transit operating costs (for motorbus, demand responsive, and rail) over the past five years [4]
- Transit fares were assumed to increase, over the next ten years, at an average annual rate of 3.5%, from a current 1996 base value of $0.85 per passenger trip. This is a conservative assumption, since transit data6 indicate that transit fares have actually increased by nearly 6.0% per year over the past ten years.
- Transit service provided, as measured by annual vehicle revenue miles, was assumed to increase at the same average annual rate as transit service has expanded over the past five years. National trends[5] indicate that annual revenue vehicle miles increased, over the past five years, at an average annual rate of 1 .0% for motorbus operations, 8.0% for demand responsive transit, and 0.5% for rail operations.
- Transit vehicle fleets, as measured by total number of vehicles available for maximum service, were assumed to increase at the same annual rate as has been experienced by transit properties over the past five years. This analysis assumed average annual increases in transit vehicle fleets of 0.5% for motorbus operations, 3.0% for demand responsive transit, and 0.3% for rail systems.

A summary of these assumptions, for motorbus, demand responsive transit, and rail operations is presented in Table 3.

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3 'Guidelines and Discount Rates for Benefit-Cost Analyses of Federal Programs;' Office of Management and Budget: Circular No. A-94 (revised), Transmittal Memorandum No. 64; October 29, 1992.

4 Sources: 'National Transit Summaries and Trends;' Section 15 1993 Transit Reports; Federal Transit Administration; May 1995. 'Transit Fact Book, 1994-l 995;' American Public Transit Association; February 1995.

5 'National Transit Summaries and Trends;' Section 15 1993 Transit Reports; Federal Transit Administration; May 1995.

6 ibid.

7 ibid.

Table 3 Summary of Analysis Assumptions

Analysis Assumptions [Average annual rates]	Motorbus	Demand Responsive	Rail
OMB recommended discount rate	7.0%	7.0%	7.0%
Transit ridership	0.0%	0.0%	0.0%
Transit operating costs	2.5%	2.5%	2.5%
Transit fares	3.5%	3.5%	3.5%
Transit vehicle revenue miles	1.0%	8.0%	0.5%
Transit vehicle fleet	0.5%	3.0%	0.3%

5.0 Transit Management System Benefits

Transit management systems refer to a broad range of APTS technologies designed to improve the planning, scheduling of transit services and the operations of transit vehicle fleets. These technologies include:

- Advanced Vehicle and control center communication systems
- Automatic Vehicle Location and Monitoring (AVUAVM) systems
- Automated Passenger Counters (APC)
- Automated software systems for transit route planning, scheduling, and operations.

Over the past decade, there has been widespread application of these technologies in the United States and Canada. Most notable are those applications that involve the integration of advanced vehicle/control center communication systems with AVUAVM systems. Recent studies[8] indicate that there are nearly 75 transit systems in the U.S. and at least six Canadian transit authorities that have AVM/AVL systems operational, under installation, or under planned implementation. Over the past decade, many of these applications have utilized wayside signposts and vehicle based communications to determine and relay the location of transit vehicles to a central dispatch center. Currently, there are over 16 deployments of signpost/odometer-based AVM/AVL systems in the U.S. and Canada. Primary limitations most often associated with these systems are: decreased flexibility in changing transit route structures; restricted monitoring of transit fleets to only signpost equipped routes; and generally higher costs for signpost installation and maintenance. Most recent installations and generally all planned new implementations of AVM/AVL systems are using Global Positioning System (GPS) navigation technology for monitoring transit vehicle fleets. GPS-based AVM/AVL systems utilize signals transmitted from a network of 24 satellites, and onboard vehicle GPS receiver/communication units to determine the location of the vehicle and relay this information to central dispatch. Area coverage with GPS-based AVM/AVL systems is generally considered

8 'Advanced Public Transportation Systems: The State of the Art - Update '96' The Volpe Center, U.S. Department of Transportation; January, 1996.
'ITS Technologies in Public Transit: Deployment and Benefits;' ITS America; February 1995.

Better than that provided by wayside signpost systems; however, in certain areas fleet coverage may be limited[9] due to impeded GPS signal reception.

As a basis for estimating current and projected APTS transit management system benefits, this analysis considered a total of 73 deployments of AVM/AVL systems that are currently operational, under implementation, or planned. These applications were identified based on a recent review[10] of APTS system deployments within the transit industry. Figure 3 presents the distribution of transit motorbus and demand-responsive

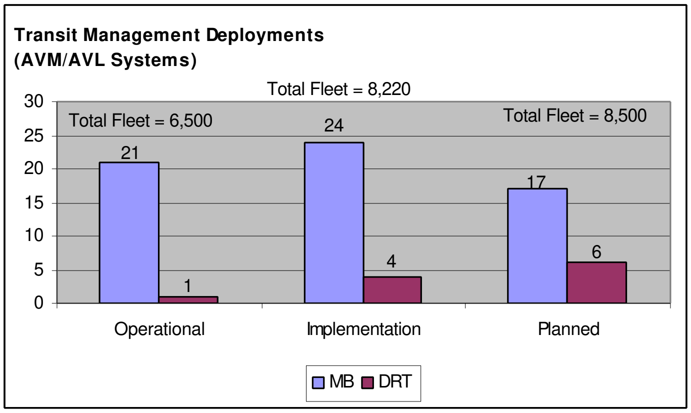

Figure 3 Transit Management Deployments

AVM/AVL system applications considered to be operational, under implementation, or planned for implementation over the next ten years.As shown, 21 AVM/AVL system deployments, encompassing a total fleet of over 6,500 motorbus (MB) and demand responsive transit (DRT) vehicles are considered to be operational. Another 28 AVM/AVL system applications, with a total fleet of over 8,220 motorbus and DRT vehicles are currently under installation. A total of 23 fleet management System deployments, with over 8,500 transit vehicles, are being planned over the next 5-6 years. A listing of the motorbus and demand responsive transit systems in each of these categories is presented in Appendix-C.

Major deployment of APTS transit management systems[11] are currently operational in Denver, CO; Seattle, WA; San Francisco, CA; Tampa, FL; San Antonio, TX; Louisville, KY; Albany, NY; Newark, NJ; Columbus, OH; Milwaukee, WI; and Norfolk, VA; Applications of APTS fleet management systems, that are currently under installation (or demonstration testing) include: Tucson, AZ; Kansas City, MO; Dallas, TX; Miami, FL; Atlanta, GA; Los Angeles, CA; Oakland, CA; Baltimore, MD; Cincinnati, OH; Detroit, MI; and Buffalo, NY.

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9 GPS satellite coverage area includes all of North America. GPS navigation coverage may be limited in those areas where the satellite signal may be impeded by tall buildings, tunnels, or other signal obstructions.

10 ‘ Advanced Public Transportation Systems: The State of the Art-Update ‘ 96’ The Volpe Center, U.S. Department of Transportation; January, 1996.
‘ Advanced Public Transportation Systems: APTS Deployments in the U.S.’ Preliminary Draft Report; The Volpe Center, U.S. Department of Transportation; January, 1996

11 Fleet Management Systems includes AVM/AVL, advanced vehicle communications, and centralized fleet dispatch and control.

The primary benefits most often cited by transit agencies with the deployment of APTS transit management systems include:

- Increased transit safety and security for both drivers and transit users.
- Improved operating efficiency with potential reductions in fleet requirements and non-revenue vehicle miles (non-revenue vehicle hours).
- More uniform and reliable transit service that promote increased ridership.
- Improved response to transit service disruptions (i.e., route, traffic, and vehicle breakdown disruptions).
- Increased control of fleet and driver operations and fleet dispatch functions.
- Improved information for transit route planning and vehicle/driver scheduling systems.
- Increased information for integration with other transit APTS technologies (e.g., transit information systems, route/stop annunciators, and vehicle passenger counters).
- Increased information for integration into other ITS technologies (e.g., traffic signal preemption systems, traffic flow metering, etc.)

Specifically, some of the benefits reported by transit agencies (or other transportation literature sources) in these areas are summarized below.

- **Increased transit safety and security.** The integration of AVM and advanced vehicle communications technologies can significantly increase the safety and security of both transit drivers and riders. For many transit agencies, (i.e., Seattle, Toronto, Denver, and Baltimore), the issues of transit safety and security were primary factors in decisions to install AVM/AVL transit management systems. The monitoring of vehicle movements and ability to respond to silent alarms have increased the sense of transit security and improved the response to transit emergencies and incidents. Many transit agencies have reported[12] reductions in emergency response times of up to 40%.
- **Improved operating efficiency.** Another major benefit area associated with transit management systems is improved efficiency in the operations of transit vehicle fleets and drivers. Most transit agencies incorporate layover times at the end of each trip, with the objective of preventing delays that develop in one trip from carrying over into the next trip. On average, it is reported[13] that the time transit vehicles/drivers spend in layover can cause a vehicle to be in non-revenue service 20%-25% of the time. By knowing the precise location of its vehicle fleet, transit dispatch centers can monitor and control fleet movements, reduce headway dispersion and platooning of vehicles, and reduce vehicle layover and non-revenue

12 ‘ ITS Technologies in Public Transit: Deployments and Benefits;’ ITS America; November 1995.

13 ‘ Vehicle Location/Driver Communication Technologies Combine to Increase Efficiency and Reduce Costs;’ Mass Transit; November/December 1992.

deadhead times. Preliminary results from initial fleet management system deployments have provided reductions in overall transit fleet requirements and non-revenue service time and mileage. The Kansas City Area Transportation Authority (KCATA) reported[14] a 23% improvement in schedule adherence, that allowed KCATA to revise their current schedules and reduce the number of buses serving the routes by seven buses (out of a total of 200 vehicles) and reassign these vehicles to service other transit routes. Other transit agencies have reported[15] reductions in fleet requirements ranging from 2% to 5% as a result of efficiencies in fleet utilization.

- **Improved transit service.** Transit management systems provide transit agencies increased flexibility to monitor and control their transit fleets and ensure adherence to published transit schedules. Some recent deployments of AVM/AVL systems have demonstrated improvements in overall schedule adherence. The Maryland Mass Transit Administration (MTA) reported[16] a 23% improvement in on-time performance on its AVL-equipped buses; while in Milwaukee, preliminary results showed that its fleet on-time performance improved from 90% to 94%, even though its fleet management system is not fully operational. In Toronto, which has one of the largest AVM/AVL deployments,[17] reported that its AVL system has significantly improved the quality of its transit service and estimated[18] that these improvements would conservatively result in a 0.5% to 1.0% increase in ridership and revenues.

- **Improved transit information.** AVM/AVL system applications also provide benefits in the form of improved transit information and integration with other APTS technologies. Many transit agencies are implementing AVM/AVL systems to provide information for their transit route planning and scheduling functions and their transit information systems. In Denver, Baltimore, Kansas City, and Seattle, AVM/AVL deployments are being used to develop tighter, more efficient schedules and to reduce the time and costs associated with conducting route schedule adherence checks. Other transit systems are employing AVM/AVL systems to provide up-to-date schedule information to its transit riders through its transit information systems. Integration of transit fleet management data with public transit information systems have been demonstrated in Minneapolis, Seattle, and Toronto and are planned in deployments for Atlanta, Portland, OR; Newark, and New York. Plans are also underway in Atlanta, Portland, OR; Chicago, New York, and Houston to link AVM/AVL deployments with traffic signal pre-emption and freeway access control systems.

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l4 'Kansas City Area Transportation Authority-Automatic Vehicle Locator System Feasibility Study:' prepared for the KCATA by Wornall Electronics and Dobies Associates; undated.

15 ' ITS Technologies in Public Transit: Deployments and Benefits:' ITS America: November 1995.

16 ' Smart Bus, Passenger and Driver Safety Ripen;' article published in Metro magazine; May/June 1994.

l7 The Toronto Transit Commission (TTC) has one of the largest deployments (2300 vehicles) of a signpost AVL system in North America. The TTC AVL system was initiated prior to 1985 and the entire system has been operational since 1992.

18 ' Communication and Information System, Evaluation Update;' Toronto Transit Commission; June 1988.

This analysis estimated the benefits of APTS fleet management systems, based on low and high estimated assumptions on efficiencies in transit operations. Benefits derived by transit agencies are in the form of reduced (or avoided) capital costs of future vehicle fleet acquisitions and reduced costs for transit fleet operations. The following equations outline the form of derived benefits, based on transit data[19] and the analysis assumptions presented in Table 4:

Table 4 Transit Management System Analysis Assumptions

	Motorbus		Demand Responsive	
	Low Estimate	High Estimate	Low Estimate	High Estimate
· average cost[20] of vehicle ($ thousands)	$225.0	$225.0	$85.0	$85.0
· reduction in vehicle fleet requirements	1%	2%	1%	2%
· reduction in non-revenue vehicle miles	5%	8%	5%	8%

Reduced Transit Fleet Acquisition Costs:

These benefits represent a one-time cost savings to a transit agency as a result of reduced or avoided costs for fleet acquisitions, following deployment of an APTS fleet management system.

[Reduced Fleet Costs] = [# vehicles] x [% reduction in fleet] x [capital cost per vehicle]

where:

[# vehicles] is the transit system's fleet requirements (number of vehicles for maximum service). For operational deployments, it reflects current fleet requirements. For deployments under implementation or planned, it reflects projected fleet requirements over the next 5 and 10 years, respectively.

[% reduction in fleet] are the assumed low/high estimates of reductions in vehicle fleet requirements.

[capital cost per vehicle] is the assumed capital cost of motorbus or demand responsive transit bus.

Reduced Transit Fleet Operating Costs:

These benefits are derived based on a one-time reduction in fleet operating costs, following deployment of an APTS fleet management system, and annual recurring savings in fleet operating costs as a result of the assumed fleet efficiency savings.

[Reduced Operating Costs] ❑ [operating cost per vehicle-mile] x [total non-revenue vehicle miles] x [% reduction in fleet non-revenue miles].

19 Benefit calculations were performed with respect to individual transit APTS transit management applications (operational, under implementation, or planned) and transit (Section 15) reporting data.

20 Capital cost of transit buses, based on data provided by the Federal Transit Administration. Motorbus costs reflect current average cost of 40' diesel motorcoach. Demand responsive vehicle cost represents average cost of an 8-10 passenger, projected 7-year average life, DRT vehicle.

where:

[operating cost per vehicle-mile] represent the transits system' s operating cost per only costs of fleet operations). For operational deployment, it reflects current fleet operating costs. For deployment under implementation or planned, it reflects projected fleet operating costs over the next five and 10 years, respectively.

[total non-revenue vehicle miles represents the transit system' s annual non-revenue vehicle miles. For operational deployments, it reflects current fleet non-revenue miles. For deployments under implementation or planned, it reflects projected fleet non-revenue miles over the next five and 10 year, respectively

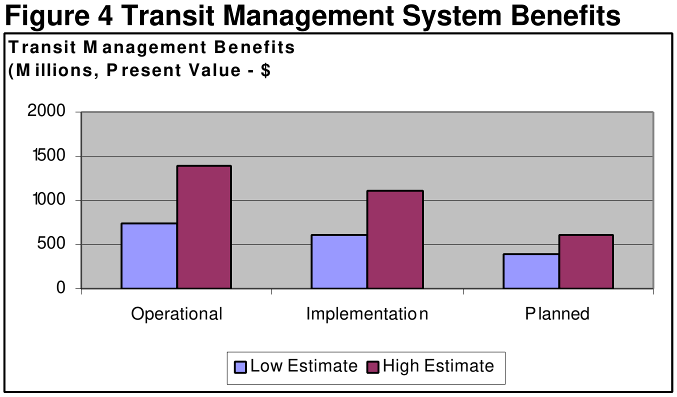
[% reduction in fleet non-revenue miles] are the assumed low/high estimates of reductions in vehicle miles.

Table 5 summarizes the total and annualized benefits (low and high estimates) projected for APTS fleet management system deployments over the next ten years. These benefits are expressed in discount 1996 present-value dollars. The total benefits (low and high estimates) for the fleet management deployments (operational, under implementations, and planned) are depicted in Figure 4.

Table 5. Transit Management System Benefits

System Deployments	Operational	Under Implementation	Planned	Total
# deployments - motorbus	**21**	**24**	**17**	**62**
# deployments DRT	1	4	6	11
total	**22**	**28**	**23**	**73**
Benefits (Low Estimate) (in thousands of discounted, present-value dollars)				
Total Benefits	$ 738,518	$ 624,191	$ 356,135	$ 1,718,844
Annualized	$ 105,148	$ 88,871	$ 50,706	$ 244,725
Benefitss (High Estimate) (in thousands of discounted, present-value dollars)				
Total Benefits	$ 1,318,590	$ 1,158,789	$ 664,154	$ 3,141,533
Annualized	$ 196,660	$ 164,985	$ 94,561	$ 456,206

Figure 4 Transit Management System Benefits



As shown, the total APTS fleet management benefits (for the 73 deployments considered) is projected at $1.7 billion (low estimate) to as high as $3.2 billion (high estimate). On an annualized basis, the benefits derived from these deployments would range from an estimated value of $244.7 million (low estimate) to as high as $456.2 million (high estimate). Forty-three percent of the total benefits are derived as a result of currently operational fleet management deployments, 36% from deployments currently under implementation, and the remaining 21% come from the planned deployments.

6.0 APTS Traveler Information System Benefits

Advanced Traveler Information Systems (ATIS) are a key element of new technology applications in transportation to provide timely and accurate information to help travelers make decisions on modes of travel, routes, and travel times. This information generally includes: transit service areas and routes, scheduled vehicle departure times, information on transfers and other transportation services, as well as fares and other transit promotions.

The technologies used to deliver this information to the consumer are varied and include media such as: telephone information systems, terminal/wayside systems, cable and interactive TV, in-vehicle displays and annunciators, and the Internet. More recent deployments of transit information systems are now coupling existing scheduled transit service information with more dynamic, real-time information on projected bus arrival times, service disruptions and delays, accidents, and recommended alternative routes or services. This real-time information is generally made available through the integration of APTS traveler information systems with other APTS technologies such as AVUAVM systems, freeway access and traffic signal systems, and centralized transportation traffic management centers.

The recent study[21] of APTS technology applications have identified over 80 deployments of APTS traveler information systems in the United States that are currently operational, under implementation, or planned. This analysis considered a total of 72 of these deployments, that provide improved information for transit trip planning, multi-modal trip services, terminal and wayside information displays and interactive kiosks, and in-vehicle electronic signs and stop annunciators. Figure 5 presents the distribution of APTS traveler information system applications considered to be operational, under implementation, or planned for implementation over the next ten years. Also depicted in Figure 5 is the distribution of the type of traveler information system technology (trip planning, terminal/wayside, and in-vehicle systems) in these major deployment categories. Appendix C lists the APTS traveler information system deployments considered in this analysis to be operational, under implementation, and planned by the transit industry.

21 Advanced Public Transportation Systems: APTS Deployments in the U.S.' Preliminary Draft Report; The Volpe Center, U.S. Department of Transportation; January, 1996.

Most notable deployments of APTS traveler information systems are currently operational or under demonstration testing in Minneapolis, Los Angeles, Denver, Seattle, Portland, OR; and San Francisco Bay Area Rapid Transit (BART). Major deployments of APTS traveler information systems currently under installation (or planned for installation over the next ten years) would include applications in Chicago, Baltimore, Houston, San Francisco (Muni), Detroit, Newark, and New York City (NYCT) transit.

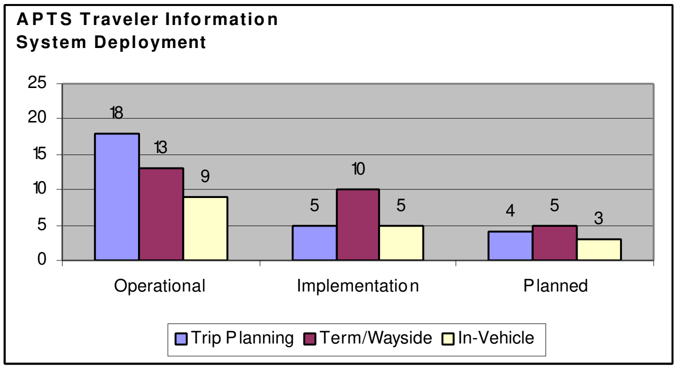


Figure 5 Traveler Information System Deployments

In Minneapolis, a federally funded demonstration project, Travlink, was initiated to improved the transit commute from the western suburbs of Minneapolis to the downtown area and to the University of Minneapolis along a 11-mile corridor of Interstate 394. Travlink employed a computer-aided dispatch/automatic vehicle location (CAD/AVL) system[22] to provide realtime vehicle location information to a transit dispatch center and to an advanced traveler information system (ATIS). This system allowed dispatchers to monitor the progress and movement of buses and provided transit commuters with updated transit arrival times on electronic signs, display monitors, information kiosks, and through video-text terminals in homes and business. [23] Results of the initial demonstration test, whichwas completed in December 1995, showed " thatTravlink has been effective in its major objective, that of providing commuters with traveler information …and that despite unexpected complications in the transit service [24] - by the end of the test, bus ridership among Travlink participants was six percent greater than that among the control group[25]."

22 For this corridor operations, the Minneapolis MTC equipped 80 buses (of its 800 vehicle fleet) with a GPS based AVL system SmartTrack TM

23 Sources: ' TheTravlink Test' article published in Mass Transit; November/December 1994 'Travlink: Getting Minneapolis to Work on Time' ; article published in GPS World; Melanie Braun and Marilyn Remer, Minnesota Guidestar; October 1995

24 Transit service was reduced during the test period and was compounded by a bus drivers' strike during the month of October 1995..

25 Source: 'Travlink: An Intelligent Commute in Minneapolis;' Clayton, Candace Minneapolis DOT; article submitted for publication in ITE Journal; updated. Also, discussions with Marilyn Remer, Project Manager Minnesota Guidestar Project, Minnesota DOT.

In Los Angeles, Caltrans is directing a Smart Traveler program[26] which provides free automated information services, such as up-to-the-minute freeway conditions and traffic speeds, customized transit route planning, and real-time ride matching, to commuters in Los Angeles County. The transit information component of this program involved the establishment of a I-800-COMMUTE telephone information service and deployment of 78 interactive kiosks, which allowed transit commuters access to Los Angeles County Metropolitan Transportation Authority's (LACMTA) bus and train schedules, route map, and fare structures. A preliminary evaluation on the commuters' use of this system showed a very positive response (80% to 85% found the system easy to use and would continue to use or encourage others to use the system).[27]

New Jersey Transit (NJT) has an extensive five-year plan to implement many APTS traveler information technologies, including an automated telephone information system, train information display systems, multimedia interactive kiosks, in-vehicle (bus and rail) displays, and terminal information displays. Results[28] from the deployment of its automated telephone information system[29] showed a significant increase (an increase of 40,000 monthly calls compared to prior year) in the volume of calls and reductions in waiting times (average call waiting time reduced from 85 to 27 seconds) of calls for transit services.

King County (Seattle) Metro, with the active participation of a non-profit organization, Overlake[30] has instituted a new electronic information system, called Riderlink. Riderlink is an on-line information resource available on the Internet that gives Seattle metropolitan area residents access to Metro routes, schedules, maps, and information on vanpool/ridematch services. Riderlink is planning expanded transit coverage by including Pierce Community Transit services along with Puget Sound ferry services. The overall objective of the program is to increase community awareness of public transportation options in the region and to reduce the number of single occupancy vehicles (SOV).[31]

The primary benefits most often cited by transit agencies with the deployment of APTS traveler information systems include:

- Increased transit ridership and revenues. Advanced traveler information systems have been found to be effective in promoting transit services to current and potential new transit patrons. The availability and ease of access to this information

26 Smart Traveler is public/private partnership directed by Caltrans in conjunction with the LACMTA, the Commuter Transportation Services, Inc., FHWA, FTA, the Health and Welfare Data Center, IBM, North Communications, and Pacific Bell.

27 'Los Angeles Smart Traveler Information Kiosks: A Preliminary Report;' paper by G. Giuliano and J. Golub; Transportation Research Record 1516, Transportation Research Board.

28 ' New Jersey Transit' s Customer Information Speeded Up by New System;' Passenger Transport; American Public Transportation Association; January 24, 1994.

29 Although the NJT automated telephone information system currently provides information rail transit schedules, NJT bus operations has also benefited by more calls to the agency on all transit services.

30 Overlake is a non-profit association of eight companies (Microsoft, Nintendo, Applied Microsystems, Allied Signal, Eddie Bauer, and others) dedicated to reducing traffic congestion in the Seattle-Puget Sound area.

31 ' Seattle' s Computerized Infosystem;' Mass Transit Journal; March/April 1995.

enhances the potential for keeping existing transit riders and attracting new users and transit revenues.

- ***Improved transit service and visibility within the community.*** The applications of advanced traveler information technologies are often used to demonstrate the full range of services and area coverage offered by public transportation in the community. This is especially true in larger metropolitan areas where extensive and more complex routes, fare structures, and multi-modal choices of transportation services often exist.
- ***Increased customer convenience***. Applications of advanced traveler information systems provide a more convenient and potentially lower cost alternative for disseminating traveler information to transit riders, as compared to published transit schedules and telephone information systems. The application of these systems, especially in high density travel areas of cities (i.e., transportation centers, major city attractions, malls, etc.) have proved to be very effective and convenient to transit riders.
- ***Enhanced compliance to Americans with Disabilities Act (ADA) requirements.*** Advanced traveler information systems, including electronic displays, annunciators, and terminal/information kiosks, are effective technologies to enhance transit services to the hearing and visually-impaired patrons and to promote an agency's compliance with ADA requirements.

This analysis assumed that the primary benefits associated with the deployment of APTS traveler information systems are accrued to transit agencies in the form of increased transit ridership and transit revenues from passenger fares. The following equation represents this relationship, based on assumed (low and high) estimates of expected increases in transit ridership with the deployment of advanced traveler information systems. Table 6 summarizes the assumptions used in the projection of these benefits.

Table 6 Traveler Information System Analysis Assumptions

	Motorbus		Demand Responsive		Rail	
	Estimate	Estimate	Estimate	Estimate	Estimate	Estimate
- % increase in transit ridership	1%	3%	1%	3%	1%	3%
· average fare per passenger trip ($ 1996)	$0.85	$0.85	$0.85	$0.85	$0.85	$0.85

Transit Ridership Benefits (increased transit revenues):

These benefits are direct recurring benefits to the transit agency, represented in the form of increased transit revenues from increased transit ridership and passenger fares.

[Increased transit revenues] = [(# annual transit passenger trips) x (assumed % increase in pax-trips) - (# annual transit passenger trips)] x [average fare per passenger trip].

where:

[# annual transit passenger trips]	represents the transit system' s total annual passenger trips. For operational TIS deployments, it reflects currents annual passenger trips. For TIS deployments under implementation or planned, it reflects projected annual passenger trips for the next five and 10 years, respectively.
[assumed % increase in passenger trips]	are the assumed low-high estimates of the passenger increase in annual passenger trips that would result from deployment of advanced traveler/transit information systems.
[average fare per passenger trip]	represents the average transit fare within the transit industry. For operational deployments, it reflects current average transit fares. For deployments under implementation or planned, it reflects projected transit fares over the next five and 10 years, respectively.

The total benefits (low and high estimates) for the 72 APTS traveler information system deployments (operational, under implementation, and planned) considered in this analysis are depicted in Figure 6. These represent total benefits, over 10 years (1996-2005), and are expressed in discounted 1996 present-value dollars.

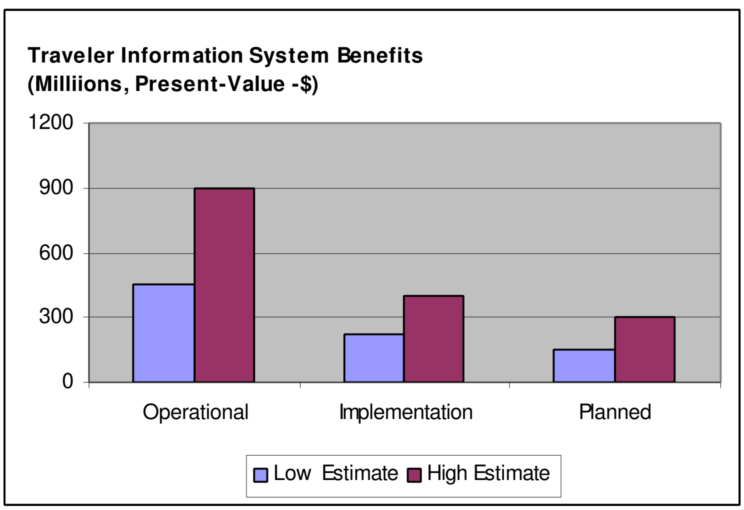


Figure 6 Traveler Information System Benefits

Table 7 summarizes the total and annualized benefits (low and high estimates) projected for the APTS transit information system deployments over the next 10 years.

Table 7 Traveler Information System Benefits

System Deployments	Operational	Under Implementation	Planned	Total
# deployments - motorbus	**34**	19	11	**64**
# deployments DRT	**2**	**0**	1	**3**
# deployments - Rail :	**4**	1	**0**	**5**
total	**40**	**20**	**12**	**72**
Benefits (Low Estimate) (in thousands of discounted present-value dollars)				
Total Beneflts	$447,902	$205,971	$142,143	$796,016
Annualized	$63.771	$29.326	$20.238	$113,335
Benefits (High Estimate) (in thousands of discounted, present-value dollars)				
Total Benefit	$895,804	$411,943	$284,286	$1,592,033
Annualized	$127,542	$58,651	$40,476	$226,669

The total APTS traveler information system benefits (for the 72 deployments considered) are projected to range from $796.0 million (low estimate) to as high as $1.6 billion (high estimate). On an annualized basis, the benefits derived from these deployments would be an estimated $113.3 million (low estimate) to as high as $226.7 million (high estimate). Of the total benefits, 56% are derived as a result of the 40 currently operational transit information deployments, 26% from 20 deployments under implementation, and the remaining 18% would come from the 12 deployments that are in the planning stage.

7.0 Electronic Fare Payment System Benefits

Electronic fare payment systems include a wide-range of automated fare collection system technologies and advanced fare media that make fare payment more convenient for the transit user and financial management of fare revenues more secure and efficient for the transportation provider. Electronic fare payment technologies are now capable of handling a variety of fare media including coins, bills, magnetic strip paper or plastic cards, and integrated circuit or radio frequency smart cards. Advances in fare media in recent years have been moving towards applications with stored value smart cards and credit cards issued by banks and other financial institutions.

Many transit agencies are looking at ways to improve their fare collection to meet a number of objectives. Primary among these are: eliminating cash and token handling to improve security of transit fares, introducing more innovative and equitable fare structures, providing increased convenience to transit riders in the purchase and payment of transit fares, and reducing overall transit costs of sorting, counting, and management of fare revenues.

Applications of advanced fare payment systems date back to the 1970s with initial applications of magnetic strip, stored value fare cards in rail transit systems in San Francisco-Oakland (BART) and Washington, DC (WMATA). Phoenix Transit was one the first bus transit systems to install magnetic card readers on electronic fare boxes in 1991. More recently, in May 1995, the authority has introduced a fare payment program using commercial credit cards, whereby fare payments are automatically debited from the transit user's credit card. Under this arrangement, the banks and financial institutions pay for the credit card media, Phoenix Transit pays the credit card companies one transaction fee per card paying passenger per month, and transit customers are billed once a month for their use of public transportation. From this program, Phoenix Transit claims[32] to have reduced fees paid to credit card companies to five cents per fare instead of 19 cents per fare transaction.

In New York City, the New York Metropolitan Transit Authority (MTA) has formed a subsidiary organization, MTA Card Company, to promote MetroCard. MetroCard is a magnetic stripe card, that will eventually be used in all NYCT subway stations. These cards would be sold in fixed denominations by the NYCT and at other outlets. Currently these cards are rechargeable and may be available for other non-transit uses, such as small purchases, telephone calls, etc.

The Washington Metropolitan Area Transit Authority (WMATA), which has implemented one of the more advanced paper magnetic strip systems (similar to that of BART in San Francisco) has recently received a one-year demonstration grant from the FTA to test a battery-powered, proximity reader/encoder smart card called the GoCard. Currently, the demonstration test includes installation of GoCard readers in 19 MetroRail stations, on 21 MetroBuses, and five park-ride lots. Long term plans call for the development of a totally integrated fare collection system that allows WMATA patrons to use one fare media on all transit systems in the Washington, DC metropolitan area.

A number of bus transit agencies are actively considering the use of Radio Frequency (RF) proximity smart cards and/or other advanced fare media for bus fares, parking fees, and inter-modal transportation services. The Ann Arbor Transportation Authority (AATA) has received a Federal Transit Administration grant to test the use of a RF proximity smart card for bus and transit parking. Applications of this smart card is tied to the University of Michigan M-Card. In California, as part of a joint effort by California Department of Transportation (Caltrans) and the FTA, eight transit authorities[33] in Ventura County are testing a proximity smart card that allows fare payment, based on a distance based fare structure, on all systems in the county. Cards can be purchased with a credit card.

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32 'Bus Fare Payment with Credit Cards in Phoenix;' draft case study report, Schwenk, J.; Volpe Center, October, 1995.

33 The largest of these transit authorities is South Coast Area Transit, which provides fixed route transit service to Oxnard, Ventura, and Port Hueneme. Other transit systems involved in this demonstration include: Camarillo, Simi Valley, Moorpark, Thousand Oaks, Fillmore, Santa Paula, and Ojai.

In the Seattle Puget Sound area, a multi-modal integrated fare demonstration project is being proposed[34] for transit agencies and other transportation services[35] in King, Snohomish, Pierce, and Kitsap Counties. An Operational test of smart fare cards is being proposed.

In Atlanta, the Metropolitan Atlanta Rapid Transit Authority (MARTA), in conjunction with VISA International and First Union Bank, are planning the introduction of a stored-value, Integrated Circuit (IC) contact-type card that can be used for transit and retail purchases. Actually, two types of cards are being proposed; one a stored-value card that is sold in fixed denominations and the other is a rechargeable card, having dollar values that can be increased and used for a wider range of purchases. Current plans are to have these cards available for use in time for the 1996 Olympics.

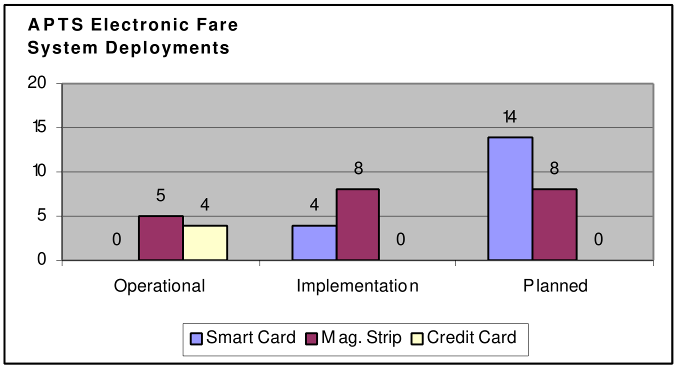

Figure 7 Electronic Fare Payment System Deployments

The recent study[36] of APTS technology applications have identified over 45 deployments of APTS electronic fare payment systems in the United States that are currently operational, under implementation, or planned. This analysis considered a total of 43 of these deployments. Figure 7 presents the distribution of APTS electronic fare payment system applications considered to be operational, under implementation, or planned for implementation over the next tem years. Also shown in this figure is the distribution of the type of automated dare system technology (magnetic strip, smart card, or credit card) in each of these major deployment categories. The APTS electronic fare payment system deployments considered in this analysis are presented in Appendix C.

The primary benefits cited by transit agencies with the deployment of APTS electronic fare payment systems include:

- ***Improved security of transit revenues.*** The introduction of advanced fare collection technologies and fare media reduces the amount of lost revenues due to fare evasion. Within the transit industry, estimates of lost revenues due to fare

34 ‘ Regional Fare and Technology Integration’ : Feasibility Study – Draft Report: Central Puget Sound Transportation Agencies; July 19, 1995

35 This demonstration would include: Seattle King County Metro, Kitsap Transit, Pierce Transit, Everett Transit, Community Transit, the Regional Transportation Authority, and Washington State Ferry System.

36 ‘ Advanced Public Transportation Systems: APTS Deployments in the U.S.’ Preliminary Draft Report; The Volpe Center, U.S. Department of Transportation, January 1996

evasions range from 4% to 8%.[37] New York City Transit which in 1993 installed a magnetic strip system received an additional revenue capture of $43 million and in 1994 an additional $54 million as a result of tightened revenue security measures and savings from reduced fare evasions. The reduction in fare evasions went from 4% to under 2%.[38]

- ***Customer convenience.*** Electronic fare payment systems improve customer convenience in the payment of transit fares and by providing a wider range of services. Electronic fare payment systems facilitate the integration of fares across regional transportation services (transit and non-transit), through a single payment media. The need for tokens, cash (exact change) and transfer slips is reduced, as well as the frequency of advanced purchases of transit fares. Electronic fare payment systems also encourage increased flexibility in fare policies (time and or distance based fares) to promote off-peak ridership or ridership by targeted market groups (e.g., employer subsidized fares for commuters, subsidized fares for the disadvantaged, etc.).
- ***Expanded base for transit revenue.*** Electronic fare payment systems provide a base of expanded revenue to transit agencies though increased marketing opportunities, interest or "float" earned on prepaid fares, transaction fees, and unused value on prepaid, stored value cards. From business case studies conducted for the New York City Transit, the MTA estimates[39] that their MetroCard system will generate increased revenues of $34.0 million from merchant fees and revenue float, $140.0 million from unused prepaid, stored value cards, and $49.0 million in revenues from new transit ridership as a result of expanded marketing opportunities.
- ***Reduced fare collection/processing costs***. Costs of handling cash and token fares are a major cost of a transit system's operating budget. Applications of electronic fare payment systems reduce agency costs in the counting and handling of cash, tokens, and transfers and, in some cases, enable these functions to be . borne by banks, credit card companies, or other financial management institutions. New Jersey Transit estimates cost savings of up to $2.7 million in reduced labor costs of handling cash and tokens.[40] Ventura County (FARETRANS) estimates that their smart card system will save the agency $9.5 million in reduced fare evasion, $5 million in reduced data collection costs, and $990,000 in reduced costs of handling fares and transfer slips.[41]
- ***More equitable, flexible fare structures.*** Advanced fare media allow transit agencies to adopt more flexible and equitable distance based fare structures, that facilitate coordinated transportation services and inter-modal transfers. These fare

37 ' Smart Cards for Transit: Multi-Use Remotely interrogated Stored-Data Cards for Fare and Toll Payment;' Final Report; The Volpe Center, U.S. DOT; April 1995.

38 ' Time to Get Smart;' article published in Mass Transit; November/December 1995.

39 ' Advanced Public Transportation System Benefits;' Federal Transit Administration; January, 1996.

40 ' ITS Technologies in Public Transit: Deployment and Benefits;' ITS America: February 1995.

41 ' Advanced Public Transportation System Benefits;' Federal Transit Administration; January, 1996.

structures would increase overall transit ridership and transit revenues. In the Los Angeles area, multi-operator fare agreements are increasing the use of mass transit, reducing traffic congestion, and increasing transit productivity. In 1993, the Los Angeles region began testing both smart card (chip embedded) and debit card (magnetic strip) technologies to integrate fare payment. As a result of increased service and fare coordination, inter-operator transfers, which accounted for less than 0.5% of all riders in 1988, had increased to at least 2% of total passengers, or 11 million boardings per year by 1994.[42]

This analysis assumed that the primary benefits associated with the deployment of APTS electronic fare payment systems are accrued to transit agencies in the form of increased transit ridership and recurring savings in passenger fare revenues. The following equation represents this relationship, based on assumed (low and high) estimates of expected savings in transit revenues and/or reductions in the costs of handling and processing transit fares. Table 8 summarizes the assumptions used in the projection of these benefits.

Table 8 Electronic Fare Payment System Analysis Assumptions

	Motorbus		Demand Responsive		Rail	
	Low Estimate	High Estimate	Low Estimate	High Estimate	Low Estimate	High Estimate
percentage of passenger fares saved	2 %	4%	2%	4%	2%	4%
average fare per passenger trip ($, 1996)	$0.85	$0.85	$0.85	$0.85	$0.85	$0.85

Electronic Fare Payment System Revenue Savings:

These benefits represent increased revenues to the transit agencies, based on an annual recurring savings in passenger fare revenues and/or reductions in the costs of handling and processing transit fares with the deployment of an APTS electronic fare payment system.

[Transit fare revenue savings] = [# annual transit passenger trips] x [% passenger fares saved] x [average fare per passenger trip].

where:

[# annual transit passenger trips]	represents the transit system's total annual passenger trips. For operational deployments, it reflects current annual passenger trips. For APTS electronic fare system deployments under implementation or planned, it reflects projected annual passenger trips for the next five and 10 years, respectively.
[% passenger fares saved]	are the assumed low/high estimates of the percentage of current and projected passenger fares that would be saved through improved automated fare collection technologies and/or transit savings in the costs of handling and processing transit fares.

42 ' A Joint Effort: Multi-Operator Fare Integration;' article published in Mass Transit; September/October 1994.

[average fare per passenger trip] represents the average transit fare within the transit industry. For operational deployments, it reflects current average transit fares. For deployments under implementation or planned, it reflects projected transit fares over the next five and 10 years, respectively.

Presented in Table 9 are the total and annualized benefits (low and high estimates projected for APTS electronic fare payment system deployments over the next 10 years. These benefits are expressed in discounted 1996 present-value dollars. The total benefits (low and high estimates) for the electronic fare payment system deployments (operational, under implementation, and planned) are depicted in Figure 8.

Table 9 Electronic Fare Payment System Benefits

System Deployments	Operational	Under Implementation	Planned	Total
# deployments motorbus	6	10	16	32
# deployments DRT	0	1	3	4
#deployment Rail	2	1	4	7
Total	8	12	23	43
Benefits (Low Estimate)				
(in thousands of discounted present-value dollars)				
Total Benefits	$ 94,770	$ 565,353	$ 619,713	$ 1,279,836
Annualized	$ 13,493	$ 80,494	$ 88,233	$ 182,220
Benefits (High Estimate)				
(in thousands of discounted present-value dollars)				
Total Benefits	$ 189,540	$ 1,130,706	$ 1,239,426	$ 2,559,672
Annualized	$ 26,986	$ 160,987	$ 176,466	$ 364,439

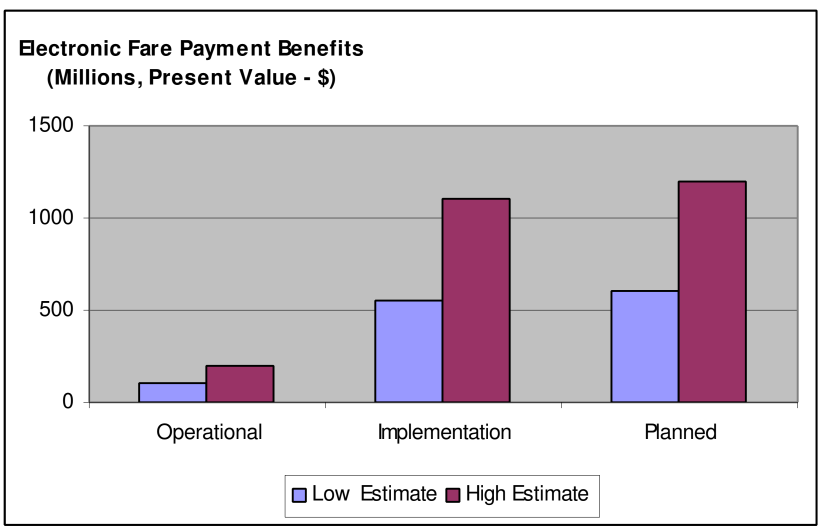

Figure 8 Electronic Fare Payment System Benefit

As shown, the total APTS electronic fare payment system benefits (for the 43 deployments considered) are projected to range from $1.3 billion (low estimate) to as high as $2.6 billion (high estimate). On an annualized basis, the benefits derived from these deployments is an estimated $182.2 million (low estimate) to as high as $364.4 million (high estimate). Of the total benefits, 8% are derived as a result of the eight currently operational automated fare system deployments, 44% from 12 deployments under implementation, and the remaining 48% would come from the 23 automated fare system deployments that are in the planning stage.

8.0 Demand Responsive Computer Aided Dispatch (CAD) System Benefits

The deployment of CAD systems for demand responsive transit and other ride-sharing services has existed in various forms over the past two decades. Early deployments of these systems have focused on vehicle dispatching as an outgrowth of automated dispatching services being implemented within the taxi industry. Within the transit industry, the applications of CAD services are directed to improve the operations of small urban and rural transit systems and to improve the services to many groups of citizens (e.g., the elderly and the disabled) that require specialized transportation services not readily available by fixed-route bus and rail systems.

The process of Demand Responsive Transit (DRT) scheduling is highly complex because of the shared-ride nature of the trips, the special needs (e.g., wheelchair accessible vehicles) of the passengers, and the constraints[43] under which transit agencies must comply to provide such services. DRT-CAD scheduling of transit services entails the recording and scheduling of incoming passenger reservations for on-demand, real-time trips or on advance reservations for trips to be taken the next day, week, or month. Passengers, vehicles and, in some cases, drivers are scheduled based upon the types of service required, time/day of week, and locale of trip origins and destinations. The vehicle routes and schedules are optimized by minimizing travel time or distance subject to the constraints of vehicle capacity and passenger desired pickup and drop-off times.

By improving how passenger ride requests are scheduled and how demand responsive vehicles are dispatched, significant benefits can be accrued by demand responsive transit systems in the following areas :

- ***Increased efficiency in transit operations.*** DRT-CAD systems can improve the efficiency of DRT operations through more efficient scheduling of vehicles/drivers to passenger trip requests, the validation of trip requests to provided transportation services, and the certification of pre-approved (subsidized) fare payments. DRT-CAD systems increase the utilization of vehicle fleets, reduce non-revenue vehicle miles (vehicle hours), reduce the costs of fleet dispatching and the recording and

43 Many of the constraints include compliance to meet the requirements of the Americans with Disabilities (ADA) Act, and with local, state, and Federal statutes dealing with the validation of passenger requirements for specialized transportation services and/or subsidized fares.

billing of services provided. In a recent evaluation[44] of computer-aided dispatching and scheduling services for the Winston-Salem Transit Authority (WSTA), showed that while total operating costs for their DRT operations[45] increased (because of increased service), the operating cost per vehicle-mile dropped by 8.5% to $1.93/vehicle-mile; their operating cost per vehicle-hour dropped by 8.6% ($2.33) to $24.70/vehicle-hour; and, their operating cost per passenger trip dropped by 2.4% to $564/passenger-trip.

- ***Improved transit service and customer convenience.*** DRT-CAD systems can provide improved transit service and convenience to customers in the form of improved response in placing DRT trip requests, through more accurate estimates of predicted pickup/drop-off times, increased flexibility in the scheduling of desired services, and reduced trip travel times.
- ***Increased compliance with transit ADA requirements.*** The Americans with Disabilities Act (ADA) of 1990 requires fixed-route transit systems to provide complementary demand-responsive transit services for passengers, who live/work within a three-quarter mile radius of a transit route, and who are unable to board a conventional transit vehicle. In addition, the ADA requirements stipulate that transit agencies are required to respond to previous-day reservations and that passengers cannot be on board the vehicle longer than one hour. DRT-CAD systems facilitate the scheduling and handling of specialized transportation requests, and ensure compliance with ADA requirements.[46]

As a basis for estimating current and projected benefits of demand responsive transit computer-aided dispatch systems, this analysis considered a total of 77 deployments of DRT-CAD systems that are currently operational, under implementation, or planned. These applications were identified based on recent review[47] of APTS system deployments within the transit industry. Figure 9 presents the distribution of DRT-CAD applications that were considered to be operational, under implementation, or planned for implementation over the next 10 years. A listing of the demand responsive transit systems in each of these categories is presented in Appendix-C.

44 ' Winston-Salem Mobility Management: An Evaluation of Computer-Aided Dispatch and Scheduling;' Paper presented at Transportation Research Board 1996 Annual Meeting; by Stone, J. Ph.D., Department of Civil Engineering, North Carolina State University; August 1, 1995.

45 The Winston-Salem Transit Authority DRT operations is one of the demonstration sites of the Federal Transit Administration's APTS Program. This evaluation focused on the WSTA's DRT operations, called Trans-AID, a 17-vehicle system that provides demand-responsive transportation services to Medicare eligible handicapped persons, elderly citizens, social service agency clients, and senior/child day care passengers. The evaluation was conducted over a six-month period from September, 1994 to February, 1995.

46 Assessment of Computer Dispatch Technology in the Paratransit Industry;' Final Report for the Federal Transit Administration, by Stone, J., Gilbert G., and Nalevanko A., University of North Carolina Institute for Transportation Research and Education; March, 1992.

47 ' Advanced Public Transportation Systems: The State of the Art - Update ' 96' The Volpe Center, U.S. Department of Transportation; January, 1996.
'Advanced Public Transportation Systems: APTS Deployments in the U.S.' Preliminary Draft Report; The Volpe Center, U.S. Department of Transportation; January, 1996.

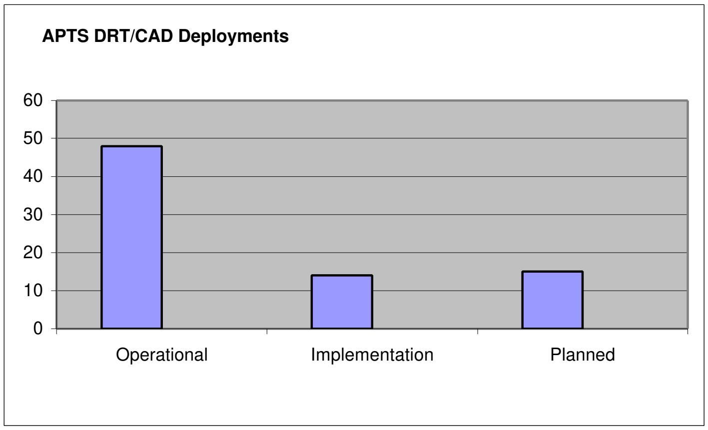

Figure 9 DRT/CAD System Deployment

This analysis estimated the benefits of APTS/DRT-CAD deployments, based low and high estimated assumptions on efficiencies in demand responsive transit operations. Benefits derived by transit agencies would be in the form of improved DRT fleet operations and in improved scheduling of fleet resources to service scheduled passenger trips. The following equation outlines the form of derived DRT-CAD beneftis, based on transit data[48] and the analysis assumptions presented in Table 10.

Table 10 Demand Responsive Transit CAD Analysis Assumption

	Demand Responsive	
	Low Estimate	High Estimate
% reduction in total fleet vehicle miles	3%	5%

Reduced Transit Fleet Operating Cost

These benefits represent savings to the transit agency as a result of a recurring reduction in fleet operating costs, following deployment of an APTS DRT-CAD system, based on assumed efficiencies in the scheduling of DRT passengers and in the routing and dispatching of demand responsive vehicle trips.

[Reduced Operating Costs] = [operating cost per vehicle-mile] x [total fleet vehicle miles] x [reduction in total fleet vehicle miles].

where:

[operating cost per vehicle mile] is the transit system' s operating cost per vehicle mile (includes only costs of fleet operations). For operational deployments, it reflects current fleet operating costs. For deployments under implementation or planned, it reflects projected fleet operating costs over the next five to 10 years, respectively.

48 Benefit calculations were performed with respect to individual transit APTS fleet management applications (operational, under implementation, or planned) and transit (Section 15) reporting data.

[total annual fleet vehicle miles] represents the transit system' s total annual vehicle miles. For operational deployments, it reflects current fleet annual vehicle miles. For deployments under implementation or planned, it reflects projected fleet vehicle miles over the next five and 10 years, respectively.

[% reduction in fleet vehicle miles] are the assumed low/high estimates of percentage reduction in annual DRT vehicle miles, as result of DRT passenger scheduling and vehicle routing/dispatching.

Table 11 presents the total and annualized benefits (low and high estimates) projected for APTS demand responsive transit CAD system deployments over the next 10 years. These benefits are expressed in discounted 1996 present-value dollars. The total benefits (low and high estimates) for the DRT-CAD system deployments (operational, under implementation, and planned) are depicted in Figure 10.

Table 11 Demand Responsive Transit CAD System Benefits

System Deployments	Operational	Under Implementation	Planned	Total
# deployments	48	14	15	77
Benefits (Low Estimate)				
(in thousands of discounted present-value dollars)				
Total Benefits	$ 34,875	$ 8,636	$ 1,169	$ 44,680
Annualized	$ 4,965	$ 1,230	$ 166	$ 6,361
Benefits (High Estimate)				
(in thousands of discounted present-value dollars)				
Total Benefits	$ 58,125	$ 14,393	$ 1,948	$ 74,466
Annualized	$ 8,276	$ 2,049	$ 277	$ 10,602

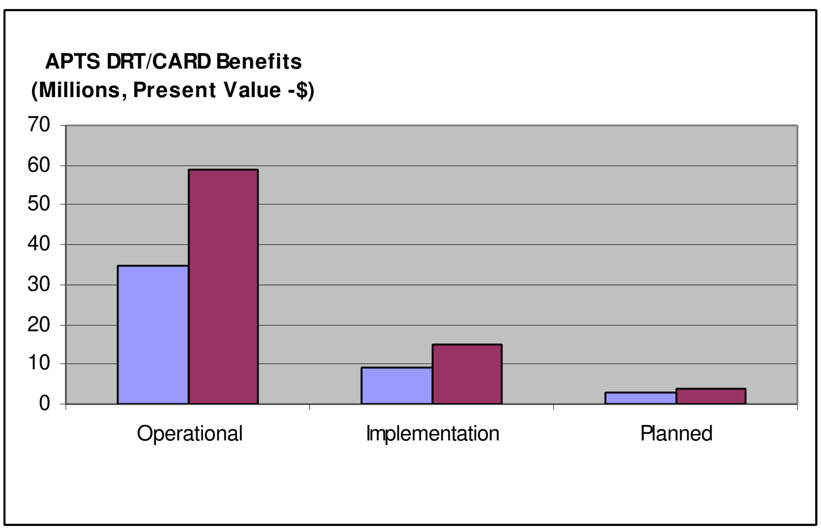

Figure 10 DRT-CAD System Benefits

The total APTS demand responsive transit CAD system benefits (for the 77 deployments considered) are projected to range from $44.6 million (low estimate) to as high as $74.5 million (high estimate). On an annualized basis, the benefits derived from these deployments are an estimated $6.4 million (low estimate) to as high as $10.6 million (high estimate). Seventy-eight percent of the total DRT-CAD benefits are derived as a result of the 48 currently operational DRT-CAD system applications, 20% from the 14 deployments under implementation, and the remaining 2% come from the 15 DRT-CAD system deployments that are in the planning stage.

9.0 Summary of Benefits

Table 12 summarizes the projected low and high estimated total benefits for the 265 APTS system deployments that are currently operational, under implementation, or planned for implementation over the next 10 years. These benefits are expressed in current (1996) discounted, present-value dollars. Also shown in the table are the projected (low and high estimate) annualized benefits that will be accrued, on an annual basis, over the next 10 years from these deployments.

Table 12 Total APTS System Benefits

	Transit Management Systems	Traveler Information Systems	Electronic Fare Payment Systems	Transit DRT- CAD Systems	Total
APTS Deployments (considered)	73	72	43	77	265
Benefits (Low Estimate) (in millionsof discounted present-value dollars)					
Total Benefits	$1,718.8	$796.0	$1,279.8	$44.7	3,839.6
Annualized	$244.7	$113.3	$182.2	$6.4	$546.6
Benefits (High Estimate) (in millions of discounted present-value dollars)					
Total Benefits	$3,204.2	$1,592.0	$2,559.7	$74.5	$7,430.4
Annualized	$456.2	$226.7	$364.4	$10.6	$1,057.9

As shown, this analysis projects the total benefits (over 10 years) from the 265 APTS system deployments would range from $3.8 billion (low estimate) to as high as $7.4 billion (high estimate). On an annualized basis, the annual APTS system benefits, over the next 10 years, from these deployments are projected to range from $546.6 million (low estimate) to as high as $1 .I million (high estimate). From the projected total APTS benefits, approximately 44% of the total benefits are accrued from fleet management system deployments, 34% from electronic fare payment system applications, 21% from traveler information system deployments, with the remaining 1% from DRT-CAD system applications. The projected total estimated (low and high) benefits for each of these APTS system deployments are depicted in Figure **II.**

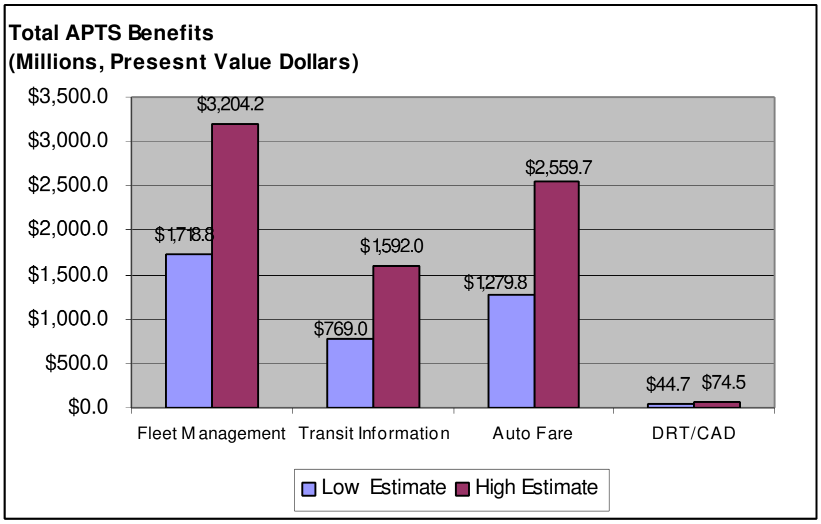

Figure 11 Total APTS System Benefits

Appendix A

Transit Systems Considered in Analysis

Table A-1 Motorbus Systems Considered

Motorbus	ST	Transit Agency	Total Vehicles Max. Service		ST	Transit Agency	Total Vehicles Max. Service
1	AK	Municipality of Anchorage	44	51	DC	Washington-WMATA	1,339
2	AL	Birmingham-Max	92	52	DE	Wilmington-DART	96
3	AL	Mobile-MTA	37	53	FL	Bradenton-MCT	9
4	AR	Fayetteville-Springdale	12	54	FL	St. Petersburg-PSTA	101
5	AZ	Tucson-Sun Tran	157	55	FL	Ft. Myers-LeeTran	26
6	AZ	Phoenix-Phoenix TS/ATC	282	56	FL	Ft. Lauderdale-Bct	184
7	AZ	Phoenix-Mesa SunRunner	9	57	FL	Daytona Beach-VOTRAN	34
8	CA	Bakersfield-GET	54	58	FL	Miami-MDTA	617
9	CA	Santa Cruz-METRO	66	59	FL	Orlando-LYNX	113
10	CA	Modesto-MAX	25	60	FL	Tallahassee-TALTRAN	41
11	CA	LA-Santa Monica	106	61	FL	West Palm-CoTran	57
12	CA	SF-SamTrans	249	62	FL	Jacksonville-JTA	135
13	CA	LA-Torrance	57	63	FL	Tampa-Hartline	133
14	CA	Stockton-SMART	55	64	FL	Miami-Red Top	171
15	CA	San Jose-SCCTD	412	65	GA	Atlanta-MARTA	561
16	CA	Oakland-AC Transit	614	66	HI	Honolulu-DTS	424
17	CA	San Francisco-Muni	386	67	IA	Cedar Rapids-The Bus	34
18	CA	SF-Golden Gate	247	68	IA	Des Moines-Metro	79
19	CA	Sacramento-RT	159	69	IA	Sioux City-STC	21
20	CA	Santa Barbara-MTD	59	70	ID	Boise Urban Stages	23
21	CA	LA-LACMTA/SCRTD	1,912	71	IL	Rock Island-Metro Link	50
22	CA	LA-Long Beach Transit	152	72	IL	Champaign-Urbana-MTD	60
23	CA	San Diego Transit	250	73	IL	Chicago-RTA-CTA	1,731
24	CA	Fresno-FAX	72	74	IL	Chicago-RTA-Pace	584
25	CA	San Bernardino-OMNITRANS	86	75	IN	NW IN-Gary-GPTC	29
26	CA	San Diego-NCTD	119	76	IN	Indianapolis-Metro	128
27	CA	Riverside-RTA	60	77	IN	Lafayette-GLPTC	34
28	CA	Oxnard-SCAT	29	78	IN	South Bend-Transpo	43
29	CA	LA-OCTA	410	79	IN	Muncie-MITS	18
30	CA	LA-Culver City	24	80	KS	Wichita-MTA	43
31	CA	LA-Montebello	36	81	KY	Louisville-TARC	248
32	CA	LA-Gardena Bus Line	38	82	KY	Cincinnati-TANK	83
33	CA	Simi Valley Transit	6	83	LA	Shreveport-SparTran	37
34	CA	Yuba-Sutter	7	84	LA	New Orleans-RTA	374
35	CA	Oakland-County Connection	100	85	MA	Boston-MBTA	841
36	CA	Palm Springs-SunBus	33	86	MA	New Bedford-SERTA	70
37	CA	Santa Maria Area Transit	6	87	MA	Boston-CATA	10
38	CA	Napa-The V.I.N.E.	13	88	MA	Providence-GATRA	28
39	CA	Visalia City Coach	10	89	MD	Baltimore-Maryland-MTA	722
40	CA	Lancaster-AV Transit	29	90	MD	Maryland-Ride-On	204
41	CA	Merced	10	91	ME	Portland-METRO	17
42	CA	LA-Foothill Transit	162	92	MI	Bay City-Metro Transit	25
43	CA	Victorville-VVTSA	33	93	MI	Detroit-SMART	233
44	CO	Denver-RTD	663	94	MI	Flint-MTA	137
45	CO	Greeley-The Bus	10	95	MI	Grand Rapids-GRATA	74
46	CT	Hartford-CT Transit	193	96	MI	Jackson-JTA	8
47	CT	Greater Bridgeport TD	38	97	MI	Ann Arbor-AATA	57
48	CT	Danbury-HART	15	98	MI	Detroit-D-DOT	412
49	CT	New Haven-CT Transit	86	99	MN	Duluth-DTA	71
50	CT	Norwalk-Wheels	17	100	MN	Minneapolis-St. Paul-MTC	855

Table A-1 Motorbus Systems Considered (continued)

Motorbus	ST	Transit Agency	Total Vehicles Max. Service		ST	Transit Agency	Total Vehicles Max. Service
101	MO	Kansas City-KCATA	208	151	PA	Philadelphia-SEPTA	1,131
102	MO	St. Louis-Bi-State	574	152	PA	Pittsburgh-PAT	735
103	MO	Columbia-CATS	10	153	PA	Beaver County-BCTA	13
104	MO	St. Joseph Express	10	154	PA	Scranton-Colts	30
105	MT	Billings-MET	16	155	PA	Williamsport-City Bus	14
106	NC	Raleigh-CAT	44	156	PA	York-YCTA	18
107	NC	Charlotte-CTS	135	157	PA	Pittsburgh-Westmoreland	12
108	NC	Fayetteville-Fast	12	158	PA	State College-Centre Line	26
109	NC	Winston-Salem-WSTA	41	159	PR	San Juan-MBA	160
110	NC	Durham-Chapel Hill	43	160	RI	Providence-RIPTA	183
111	ND	Grand Forks-City Bus	12	161	SC	Greenville-GTA	18
112	NE	Omaha-TA	126	162	SD	Rapid City Transit System	5
113	NH	Nashua-City Bus	4	163	TN	Chattanooga-CARTA	48
114	NJ	New Jersey Transit	1,656	164	TN	Knoxville-K-Trans	51
115	NJ	NJ Transit (Contract)	457	165	TN	Memphis-MATA	165
116	NM	Albuquerque-Sun Tran	108	166	TN	Nashville-MTA	96
117	NV	Reno-Citifare	53	167	TN	Clarksville-CTS	6
118	NV	Las Vegas - Citizens	218	168	TX	Amarillo-ACT	13
119	NY	Albany-CDTA	187	169	TX	El Paso-Sun Metro	118
120	NY	Buffalo-NFTA	307	170	TX	Fort Worth-The T	116
121	NY	NY-MTA-Long Island Bus	265	171	TX	Houston-Metro	1,016
122	NY	NY-MTA-NYCTA	3,064	172	TX	Laredo-El Metro	26
123	NY	Syracuse-RTA-Centro	137	173	TX	San Antonio-VIA	498
124	NY	Utica-UTA	32	174	TX	Waco Transit System	10
125	NY	NYCDOT-Green Bus	148	175	TX	Brownsville-BUS	12
126	NY	NYCDOT-Jamaica Bus	74	176	TX	Austin-Capital Metro	244
127	NY	NYCDOT-Bus Tours	100	177	TX	Corpus Christi-The B	54
128	NY	NY-Hart	10	178	TX	Dallas-DART	530
129	NY	NYCDOT-Command Bus	106	179	TX	Dallas-DART/ATE	209
130	NY	NY-Westchester-BEE-LINE	15	180	UT	Salt Lake City-UTA	420
131	NY	NY-Westchester-Liberty	241	181	VA	Newport News-Pentran	98
132	NY	New York City DOT	91	182	VA	Norfolk-TRT	124
133	NY	Rochester-RTS	178	183	VA	Richmond-GRTC	159
134	NY	NYCDOT-Queens	226	184	VA	Fairfax Connector	51
135	NY	Ithaca-TOMTRAN	30	185	VT	Burlington-CT	24
136	OH	Akron-Metro	134	186	WA	Seattle-Metro	906
137	OH	Cincinnati-SORTA	323	187	WA	Spokane-STA	115
138	OH	Cleveland-RTA	586	188	WA	Tacoma-Pierce Transit	147
139	OH	Columbus-COTA	252	189	WA	Olympia-IT	71
140	OH	Dayton-RTA	162	190	WA	Bremerton-Kitsap Transit	77
141	OH	Toledo-TARTA	161	191	WA	Vancouver-C-Tran	62
142	OH	Youngstown-WRTA	28	192	WA	Seattle-Snohomish-Commun.	150
143	OK	Oklahoma City-COTPA	65	193	WI	Kenosha-KTC	35
144	OK	Tulsa-MTA	66	194	WI	LaCrosse Municipal	14
145	OR	Eugene-LTD	65	195	WI	Madison-MMT	140
146	OR	Portland-Tri-Met	468	196	WI	Milwaukee-County	460
147	OR	Medford-RVTD	15	197	WI	Sheboygan-ST	29
148	PA	Allentown-Lanta	55	198	WI	Milwaukee-Waukesha Metro	45
149	PA	Erie-EMTA	52	199	WV	Charleston-KRT	43
150	PA	Harrisburg-Cat	52	200	WV	Huntington-TTA	20

Table A-2 Demand Responsive Transit Systems Considered

Demand Responsive Transit	ST	Transit Agency	Total Vehicles Max. Service		ST	Transit Agency	Total Vehicles Max. Service
1	AK	Municipality of Anchorage	10	54	CT	Norwalk-Wheels	13
2	AL	Mobile-MTA	19	55	CT	Waterbury-GWTD	7
3	AL	Montgomery-Community	26	56	DE	Delaware-DAST	47
4	AL	NW Alabama COLG	30	57	FL	Bradenton-MCT	18
5	AL	Huntsville	31	58	FL	St. Petersburg-PSTA	81
6	AR	Fayetteville-Springdale	2	59	FL	Ft. Myers-LeeTran	6
7	AR	Fayetteville-CRG	29	60	FL	Ft. Lauderdale-Bct	192
8	AZ	Phoenix PTD	61	61	FL	Daytona Beach-VOTRAN	4
9	AZ	Tucson-Sun Tran	48	62	FL	Miami-MDTA	27
10	AZ	Phoenix-Glendale	12	63	FL	Orlando-LYNX	70
11	AZ	Phoenix-Mesa SunRunner	22	64	FL	Tallahassee-TALTRAN	12
12	AZ	Phoenix-Maricopa STS	47	65	FL	Jacksonville-JTA	79
13	AZ	Phoenix-Sun Cities-SCAT	12	66	FL	Tampa-Hartline	86
14	AZ	Peoria Transit	4	67	FL	Sarasota-SCTA	21
15	CA	Santa Cruz-METRO	44	68	FL	Brevard-SCAT	50
16	CA	Modesto-MAX	10	69	FL	Miami-MDTA/Comprehensive	283
17	CA	SF-SamTrans	22	70	FL	Okaloosa County	30
18	CA	LA-Torrance	30	71	FL	Panama City-Bay Council	29
19	CA	Stockton-SMART	21	72	HI	Aloha-State Tour & Transp	86
20	CA	San Jose-SCCTD	15	73	HI	Honolulu-HDOT-Mayflower	135
21	CA	San Francisco-Muni	77	74	IA	Cedar Rapids-The Bus	4
22	CA	Sacramento-RT	52	75	IA	Des Moines-Metro	24
23	CA	Santa Barbara-MTD	8	76	IA	Sioux City-STC	16
24	CA	LA-Long Beach Transit	20	77	IA	Waterloo-MET	30
25	CA	Fresno-FAX	24	78	ID	Boise Urban Stages	3
26	CA	San Bernardino-OMNITRANS	65	79	IL	Rock Island-Metro Link	20
27	CA	San Diego-NCTD	26	80	IL	Chicago-RTA-CTA	695
28	CA	Riverside-RTA	10	81	IL	Chicago-RTA-Pace	313
29	CA	LA-OCTA	213	82	IL	St. Louis-MCT	30
30	CA	LA-Montebello	3	83	IN	NW IN-Gary-GPTC	2
31	CA	LA-Gardena Bus Line	7	84	IN	NWIN-LCEOC, Inc.	46
32	CA	Simi Valley Transit	2	85	IN	NW IN-Trade Winds Rehab	22
33	CA	Salinas-Monterey	21	86	IN	Indianapolis-Metro	24
34	CA	Yuba-Sutter	13	87	IN	Lafayette-GLPTC	3
35	CA	LA-LACMTA METRO	131	88	IN	South Bend-Transpo	5
36	CA	Palm Springs-SunBus	13	89	IN	Muncie-MITS	9
37	CA	Santa Maria Area Transit	5	90	IN	Elkhart Heart-City Rider	39
38	CA	Visalia City Coach	5	91	IN	NW IN-Lake County	52
39	CA	San Diego-SANDAG	43	92	IN	City of Kokomo	22
40	CA	Lancaster-AV Transit	13	93	KS	Wichita-MTA	7
41	CA	Merced	8	94	KY	Louisville-TARC	104
42	CA	City of Los Angeles	108	95	LA	Shreveport-SparTran	7
43	CA	Victorville-VVTSA	8	96	LA	New Orleans-RTA	50
44	CA	Lompoc Transit	9	97	MA	Boston-MBTA	125
45	CO	Colorado Springs Transit	46	98	MA	Brockton-BAT	33
46	CO	Denver-RTD	50	99	MA	Lowell-LRTA	22
47	CO	Greeley-The Bus	4	100	MA	Pittsfield-BRTA	53
48	CO	Fort Collins-Transfort	20	101	MA	Springfield-PVTA	54
49	CO	Grand Junction-MesABILITY	31	102	MA	Worcester-WRTA	107
50	CT	Hartford-Metro	85	103	MA	Boston-CATA	8
51	CT	New Haven-Gr. New Haven	11	104	MA	Fitchburg-MART	158
52	CT	Greater Bridgeport TD	14	105	MA	Providence-GATRA	60
53	CT	Danbury-HART	13	106	MA	Hyannis-Cape Cod-CCRTA	46

Table A-2 Demand Responsive Transit Systems Considered (continued)

Demand Responsive Transit	ST	Transit Agency	Total Vehicles Max. Service		ST	Transit Agency	Total Vehicles Max. Service
107	MD	Baltimore-Maryland-MTA	53	160	PA	Reading-BARTA	37
108	ME	Portland-RTP	14	161	PA	Scranton-Colts	10
109	ME	Bangor-Eastern Transp.	73	162	PA	Williamsport-City Bus	2
110	ME	Lewiston-Western Maine	15	163	PA	York-YCTA	8
111	MI	Bay City-Metro Transit	14	164	PA	Pittsburgh-Westmoreland	3
112	MI	Detroit-SMART	126	165	PA	State College-Centre Line	6
113	MI	Flint-MTA	59	166	PA	Pittsburgh-PAT/ACCESS	418
114	MI	Grand Rapids-GRATA	58	167	SC	Greenville-GTA	15
115	MI	Jackson-JTA	17	168	SC	Florence-PDRTA	86
116	MI	Lansing-CATA	50	169	SC	Sumter-Santee Wateree	45
117	MI	Ann Arbor-AATA	36	170	SD	Sioux Falls-The Bus	39
118	MO	Kansas City-KCATA	54	171	SD	Rapid City Transit System	5
119	MO	St. Louis-Bi-State	46	172	TN	Chattanooga-CARTA	7
120	MO	St. Joseph Express	20	173	TN	Nashville-MTA	34
121	MT	Billings-MET	10	174	TN	Clarksville-CTS	3
122	NC	Raleigh-CAT	7	175	TX	Amarillo-ACT	3
123	NC	Charlotte-CTS	37	176	TX	El Paso-Sun Metro	106
124	NC	Winston-Salem-WSTA	12	177	TX	Fort Worth-The T	20
125	NC	Durham-Chapel Hill	6	178	TX	Houston-Metro	208
126	NC	Durham-DATA	22	179	TX	Laredo-El Metro	7
127	NC	Gastonia-Gaston	24	180	TX	San Antonio-VIA	168
128	ND	Grand Forks-City Bus	9	181	TX	Waco Transit System	2
129	ND	Bis-Man Transit	20	182	TX	Brownsville-BUS	5
130	NE	Lincoln- StarTRAN	26	183	TX	Dallas - Handitran	10
131	NH	Nashua-City Bus	9	184	TX	Austin-Capital Metro	68
132	NM	Albuquerque-Sun Tran	44	185	TX	Corpus Christi-The B	22
133	NM	Santa Fe-Sr. Citizens	33	186	TX	Dallas-DART	312
134	NV	Reno-Citifare	29	187	TX	Dallas-Grand Prairie	5
135	NV	Las Vegas-EOB	23	188	UT	Salt Lake City-UTA	54
136	NY	NY-MTA-NYCTA	104	189	VA	Newport News-Pentran	21
137	NY	Poughkeepsie-LOOP	21	190	VA	Norfolk-TRT	59
138	NY	Utica-UTA	5	191	VA	Richmond-GRTC	24
139	NY	NY-Hart	4	192	VA	Charlottesville-Jaunt	42
140	NY	NY-Westchester-BEE-LINE	36	193	VT	Burlington-CT	8
141	NY	New York City DOT	92	194	WA	Seattle-Metro	174
142	NY	Ithaca-TOMTRAN	9	195	WA	Spokane-STA	68
143	OH	Akron-Metro	76	196	WA	Tacoma-Pierce Transit	106
144	OH	Cincinnati-SORTA	29	197	WA	Richland-Ben Franklin	41
145	OH	Cleveland-RTA	67	198	WA	Bremerton-Kitsap Transit	72
146	OH	Dayton-RTA	48	199	WA	Bellingham-WTA	20
147	OH	Hamilton City Lines	8	200	WA	Seattle-Snohomish-Senior	24
148	OH	Youngstown-WRTA	4	201	WI	Appleton-Valley Transit	25
149	OH	Cleveland-LAKETRAN	39	202	WI	Green Bay-GBT	60
150	OH	Newark	28	203	WI	Kenosha-KTC	2
151	OK	Oklahoma City-COTPA	40	204	WI	Madison-MMT	158
152	OK	Tulsa-MTA	38	205	WI	Racine-Belle Urban System	20
153	OR	Portland-Tri-Met	88	206	WI	Sheboygan-ST	5
154	OR	Medford-RVTD	5	207	WI	Milwaukee-Waukesha Metro	4
155	PA	Allentown-Lanta	55	208	WI	Milwaukee-Paratransit	295
156	PA	Erie-EMTA	24	209	WV	Charleston-KRT	8
157	PA	Lancaster-RRTA	70	210	WV	Huntington-TTA	4
158	PA	Philadelphia-SEPTA	246	211	WY	City of Casper	9
159	PA	Beaver County-BCTA	17	212	WY	Cheyenne Transit	29

Table A-3 Rail Transit Systems Considered

Rail	ST	Transit Agency	Total Vehicles Max. Service
Heavy Rail			
1	NY	NY-MTA-NYCTA	4,954
2	IL	Chicago-RTA-CTA	856
3	DC	Washington-WMATA	534
4	CA	San Francisco-BART	406
5	MA	Boston-MBTA	378
6	PA	Philadelphia-SEPTA	304
7	NY	Port Authority-PATH	282
8	GA	Atlanta-MARTA	160
9	NJ	Philadelphia-PATCO	102
10	FL	Miami-MDTA	76
11	MD	Baltimore-Maryland-MTA	48
12	NY	NY-MTA-Staten Island	36
13	OH	Cleveland-RTA	35
14	CA	LA-LACMTA/SCRTD	16
Light Rail			
1	MA	Boston-MBTA	194
2	PA	Philadelphia-SEPTA	107
3	CA	San Francisco-Muni	101
4	CA	San Diego- The Trolley	59
5	PA	Pittsburgh-PAT	59
6	CA	San Jose-SCCTD	38
7	CA	LA-LACMTA/SCRTD	36
8	CA	Sacramento-RT	32
9	MD	Baltimore-Maryland-MTA	30
10	OH	Cleveland-RTA	24
11	OR	Portland-Tri-Met	23
12	NY	Buffalo-NFTA	23
13	LA	New Orleans-RTA	21
14	NJ	New Jersey Transit	16
15	TN	Memphis-MATA	4
16	WA	Seattle-Metro	3

Appendix B

Section 15 Transit Reporting Data **Used** in Analysis

Table B-I Section 15 Transit Reporting Data

Transit Operating Expenses
- Vehicle Operations
- Vehicle Maintenance
- Non-Vehicle Maintenance
- General and Administrative
- Purchased Transportation

Transit Service Characteristics
- Feet size - total
- Vehicles operated - base period
- Vehicles operated - peak period
- Vehicles operated - maximum service
- Vehicles available - maximum service
- Route miles
- Number employees
- Employee work-hours
- Number roadcalls
- Number of service interruptions

Transit Safety
- Number of incidents (collision, non-collision, station)
- Number of fatalities (patron, non patron, total)
- Number of injuries (patron, non patron, total)

Transit Service Supplied
- Scheduled annual vehicle revenue miles
- Actual annual vehicle miles
- Actual annual vehicle hours
- Actual annual vehicle revenue miles
- Actual annual vehicle revenue hours

Transit Service Consumed
- Annual unlinked passenger trips
- Annual passenger miles

Appendix C

APTS Deployments

Table C-1 APTS Fleet Management System Deployments

Operational	ST	Transit Agency	MB	DRT
1	CA	LA-Santa Monica	106	
2	CA	SF-SamTrans	249	
3	CA	San Francisco-Muni	386	
4	CA	LA-Gardena Bus Line	38	
5	CA	Napa-The V.I.N.E.	13	
6	CO	Denver-RTD	663	
7	FL	Tampa-Hartline	133	
8	IA	Des Moines-Metro	79	24
9	KY	Louisville-TARC	248	
10	NJ	New Jersey Transit	1,656	
11	NY	Albany-CDTA	187	
12	NY	NY-Westchester-Liberty	241	
13	OH	Columbus-COTA	252	
14	OR	Eugene-LTD	65	
15	PA	Scranton-Colts	30	
16	PA	Rochester - Beaver County	13	
17	TX	San Antonio-VIA	498	
18	VA	Norfolk-TRT	124	
19	WA	Seattle-Metro	906	
20	WI	Milwaukee-County	460	
21	WI	Sheboygan-ST	29	

Table C-1 APTS Fleet Management System Deployments (cont'd)

Under Implementation

	ST	Transit Agency	MB	DRT
1	AZ	Tucson-Sun Tran	157	
2	CA	Santa Cruz-METRO	66	
3	CA	Stockton-SMART	55	
4	CA	San Jose-SCCTD		15
5	CA	Oakland-AC Transit	614	
6	CA	LA-LACMTA/SCRTD	1,912	
7	FL	Ft. Lauderdale-Bct	184	
8	FL	Miami-MDTA	617	
9	GA	Atlanta-MARTA	561	
10	IA	Cedar Rapids-The Bus	34	
11	IL	Chicago-RTA-Pace	584	
12	IN	NW IN-Gary-GPTC	29	
13	LA	Shreveport-SparTran	37	
14	MA	Boston-CATA	10	
15	MD	Baltimore-Maryland-MTA	722	
16	MD	Maryland-Ride-On	204	
17	MI	Detroit-SMART	233	126
18	MI	Ann Arbor-AATA	57	
19	NC	Raleigh-CAT		7
20	NY	Buffalo-NFTA	307	
21	NY	Rochester-RTS	178	
22	OH	Cincinnati-SORTA	323	
23	OR	Portland-Tri-Met	468	
24	TX	Corpus Christi	54	
25	TX	Dallas-DART	530	
26	WA	Bremerton-Kitsap Transit	77	72

Planned

	ST	Transit Agency	MB	DRT
1	AZ	Phoenix PTD		61
2	AZ	Phoenix-Phoenix TS/ATC	282	
3	CA	LA-Torrance	57	
4	CA	Modesto-MAX	25	10
5	CA	San Bernardino-OMNITRANS	86	
6	IA	Sioux City-STC	21	16
7	IL	Chicago-RTA-CTA	1,731	
8	IL	Rock Island-Metro Link	50	
9	LA	New Orleans-RTA	374	
10	MA	Attleboro/Taunton-GATRA		28
11	MN	Minneapolis-St. Paul-MTC	855	
12	MO	Kansas City-KCATA	208	
13	NC	Fayetteville-Fast	12	
14	NC	Winston-Salem-WSTA		12
15	NM	Albuquerque-Sun Tran		44
16	NY	NY-MTA-Long Island Bus	265	
17	NY	NY-MTA-NYCTA	3,064	
18	NY	Syracuse-RTA-Centro	137	
19	TX	El Paso-Sun Metro	118	
20	TX	Houston-Metro	1,016	
21	WI	Kenosha Transit	35	

Table C-2 APTS Transit Information System Deployments

Operational					
	ST	Transit Agency	MB	DRT	RAIL
1	CA	LA-LACMTA/SCRTD	1,912		
2	CA	LA-LACMTA/SCRTD			16
3	CA	LA-Long Beach Transit	152		
4	CA	Napa-The V.I.N.E.	13		
5	CA	Riverside - Special Transportation		19	
6	CA	San Francisco-BART			406
7	CA	Santa Barbara-MTD	59		
8	CA	SF-SamTrans	249		
9	CA	Stockton-SMART	55		
10	CO	Denver-RTD	663		
11	CO	Greeley-The Bus	10		
12	CT	Hartford-CT Transit	193		
13	DC	Washington-WMATA	1,339		
14	FL	Daytona Beach-VOTRAN	34		
15	FL	Miami-MDTA	617		
16	FL	Tampa-Hartline	133		
17	HI	Honolulu-DTS	424		
18	IA	Des Moines-Metro	79		
19	IL	Chicago-RTA-Pace	584		
20	KS	Wichita-MTA	43		
21	LA	New Orleans-RTA	374		
22	MA	Boston-MBTA			378
23	MN	Minneapolis-St. Paul-MTC	855		
24	MO	Columbia-CATS	10		
25	NC	Charlotte-CTS	135		
26	NC	Winston-Salem-WSTA	41	12	
27	NV	Las Vegas - Citizens	218		
28	NY	Rochester-RTS	178		
29	OH	Columbus-COTA	252		
30	OR	Portland-Tri-Met	468		23
31	PA	Beaver County-BCTA	13		
32	PA	Scranton-Colts	30		
33	PA	State College-Centre Line	26		
34	PA	Williamsport-City Bus	14		
35	VA	Newport News-Pentran	98		
36	WA	Seattle-Metro	906		
37	WI	Kenosha-KTC	35		
38	WI	Milwaukee-Waukesha Metro	15		

Table C-2 APTS Transit Information System Deployments (cont'd)

Under Implementation

	ST	Transit Agency	MB	DRT	RAIL
1	AZ	Tucson-Sun Tran	157		
2	CA	Oakland-AC Transit	614		
3	CA	Santa Cruz-METRO	66		
4	GA	Atlanta-MARTA	561		160
5	IL	Chicago-RTA-CTA	1,731		
6	IL	Rock Island-Metro Link	50		
7	MA	Boston-CATA	10		
8	MD	Baltimore-Maryland-MTA	722		
9	MD	Maryland-Ride-On	204		
10	ME	Portland-METRO	17		
11	MI	Ann Arbor-AATA	57		
12	NC	Raleigh-CAT	44		
13	NY	Buffalo-NFTA	307		
14	OH	Cincinnati-SORTA	323		
15	TX	Corpus Christi	54		
16	TX	Houston-Metro	1,016		
17	TX	Laredo-El Metro	26		
18	WA	Bremerton-Kitsap Transit	77		
19	WA	Spokane-STA	115		

Planned

	ST	Transit Agency	MB	DRT	RAIL
1	CA	LA-Torrance	57		
2	CA	San Francisco-Muni	386		
3	ID	Boise Urban Stages	23		
4	MI	Detroit-SMART	233		
5	ND	Grand Forks-City Bus	12		
6	NJ	New Jersey Transit	1,656		
7	NY	NY-MTA-Long Island Bus	265		
8	NY	NY-MTA-NYCTA	3,064		
9	NY	Syracuse-RTA-Centro	137		
10	NY	NY-Westchester-Liberty	241		
11	WA	Tacoma-Pierce Transit	147		
12	WI	Madison-MMT		158	

Table C-3 APTS Automated Fare System Deployments

Operational

	ST	Transit Agency	MB	DRT	RAIL
1	AZ	Phoenix-Mesa SunRunner	9		
2	AZ	Phoenix-Phoenix TS/ATC	282		
3	CA	LA-Culver City	24		
4	CA	LA-Foothill Transit	162		
5	CA	LA-LACMTA/SCRTD (HR/LR)			52
6	CA	LA-Montebello	36		
7	CA	San Francisco-BART			406
8	CT	Hartford-CT Transit	193		

Implementation

	ST	Transit Agency	MB	DRT	RAIL
1	CA	Lompoc Transit		9	
2	GA	Atlanta-MARTA	561		160
3	IL	Chicago-RTA-CTA	1,731		
4	MA	Boston-CATA	10		
5	NY	New York City DOT	91		
6	NY	NY-MTA-NYCTA	3,064		
7	NY	NY-Westchester-Liberty	241		
8	NY	NYCDOT-Bus Tours	100		
9	NY	NYCDOT-Command Bus	106		
10	NY	NYCDOT-Green Bus	148		
11	NY	NYCDOT-Queens	226		

Planned

	ST	Transit Agency	MB	DRT	RAIL
1	CA	LA-Gardena Bus Line		7	
2	CA	LA-Torrance	57		
3	CA	Santa Cruz-METRO	66		
4	CA	Simi Valley Transit	6		
5	DC	Washington-WMATA	1,339		534
6	DE	Wilmington-DART	96		
7	FL	Tallahassee-TALTRAN	41		
8	MA	Boston-MBTA	841		378
9	MI	Ann Arbor-AATA	57		
10	NC	Winston-Salem-WSTA		12	
11	NV	Reno-Citifare	53		
12	NY	NY-MTA-NYCTA			4,954
13	NY	Port Authority-PATH			282
14	PA	Pittsburgh-Westmoreland	12		
15	TN	Chattanooga-CARTA	48		
16	TX	Dallas-Grand Prairie		5	
17	TX	San Antonio-VIA	498		
18	WA	Seattle-Metro	906		
19	WA	Seattle-Snohomish-Commun.	150		
20	WA	Tacoma-Pierce Transit	147		
21	WV	Huntington-TTA	20		

Table C-3 APTS Demand Responsive CAD System Deployments

Operational

	ST	Transit Agency	DRT
1	AL	Huntsville	31
2	AR	Fayetteville-Springdale	2
3	AZ	Phoenix-Glendale	12
4	CA	San Jose-SCCTD	15
5	CA	Santa Maria Area Transit	5
6	CT	Danbury-HART	13
7	FL	Daytona Beach-VOTRAN	4
8	FL	Miami-MDTA	27
9	FL	Miami-MDTA/Comprehensive	283
10	FL	Okaloosa County	30
11	FL	Panama City-Bay Council	29
12	HI	Honolulu-HDOT-Mayflower	135
13	IA	Watreloo MTA of Hawk County	30
14	IN	Lafayette-GLPTC	3
15	IN	South Bend-Transpo	5
16	KS	Wichita-MTA	7
17	MA	Lowell-LRTA	22
18	MA	Springfield-PVTA	54
19	MA	Fitchburg-MART	158
20	MA	Providence-GATRA	60
21	ME	Portland-RTP	14
22	ME	Lewiston-Western Maine	15
23	MI	Jackson-JTA	17
24	MI	Lansing-CATA	50
25	MO	St. Louis-Bi-State	46
26	MT	Billings-MET	10
27	NC	Charlotte-CTS	37
28	NC	Winston-Salem-WSTA	12
29	NC	Durham-DATA	22
30	ND	Grand Forks-City Bus	9
31	NV	Reno-Citifare	29
32	NV	Las Vegas-EOB	23
33	NY	Poughkeepsie-LOOP	21
34	NY	Utica-UTA	5
35	NY	NY-Westchester-BEE-LINE	36
36	OH	Youngstown-WRTA	4
37	PA	York-YCTA	8
38	SC	Greenville-GTA	15
39	TN	Clarksville-CTS	3
40	TX	Amarillo-ACT	3
41	TX	Laredo-El Metro	7
42	TX	San Antonio-VIA	168
43	TX	Brownsville-BUS	5
44	VT	Burlington-CT	8
45	WA	Tacoma-Pierce Transit	106
46	WA	Seattle-Snohomish-Senior	24
47	WV	Charleston-KRT	8
48	WY	City of Casper	9

Under Implementation

	ST	Transit Agency	DRT
1	CA	Stockton-SMART	21
2	LA	Shreveport-SparTran	7
3	MI	Detroit-SMART	126
4	MO	St. Joseph Express	20
5	NC	Raleigh-CAT	7
6	NC	Durham-Chapel Hill	6
7	NH	Nashua-City Bus	9
8	NY	Ithaca-TOMTRAN	9
9	OH	Hamilton City Lines	8
10	SC	Sumter-Santee Wateree	45
11	TX	Dallas - Handitran	10
12	TX	Corpus Christi-The B	22
13	WA	Bremerton-Kitsap Transit	72
14	WI	Madison-MMT	158

Planned

	ST	Transit Agency	DRT
1	AZ	Phoenix PTD	61
2	AZ	Phoenix-Maricopa STS	47
3	AZ	Peoria Transit	4
4	CA	Modesto-MAX	10
5	CA	Yuba-Sutter	13
6	CA	Lancaster-AV Transit	13
7	CA	Victorville-VVTSA	8
8	CT	New Haven-Gr. New Haven	11
9	CT	Greater Bridgeport TD	14
10	IA	Cedar Rapids-The Bus	4
11	IA	Sioux City-STC	16
12	IN	NW IN-Trade Winds Rehab	22
13	MI	Bay City-Metro Transit	14
14	OR	Medford-RVTD	5
15	WI	Milwaukee-Waukesha Metro	4

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