ITS Technologies in Public Transit: Deployment & Benefits

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ITS Technologies in Public Transit

1. In late 1994 and early 1995, a study of the deployment of ITS technologies was conducted. This study surveyed 35 transit agencies to ascertain the extent of deployment and they either realized or perceive benefits of these technologies. The analysis consists of data from 18 agencies having fleets of 800 buses or more, and 18 agencies having approximately 200 buses. In addition, more recent data from a few other agencies are included since the initial study was completed.

It should be noted that the Volpe National Transportation Center is in the process of surveying the rest of the transit agencies in the U.S. to determine the complete extent of deployment.

This analysis was aimed at three principal objectives:

- Defining extent of deployment of ITS technologies
- Defining the extent of the desire to deploy ITS technologies
- Defining the benefits to be derived from these technologies

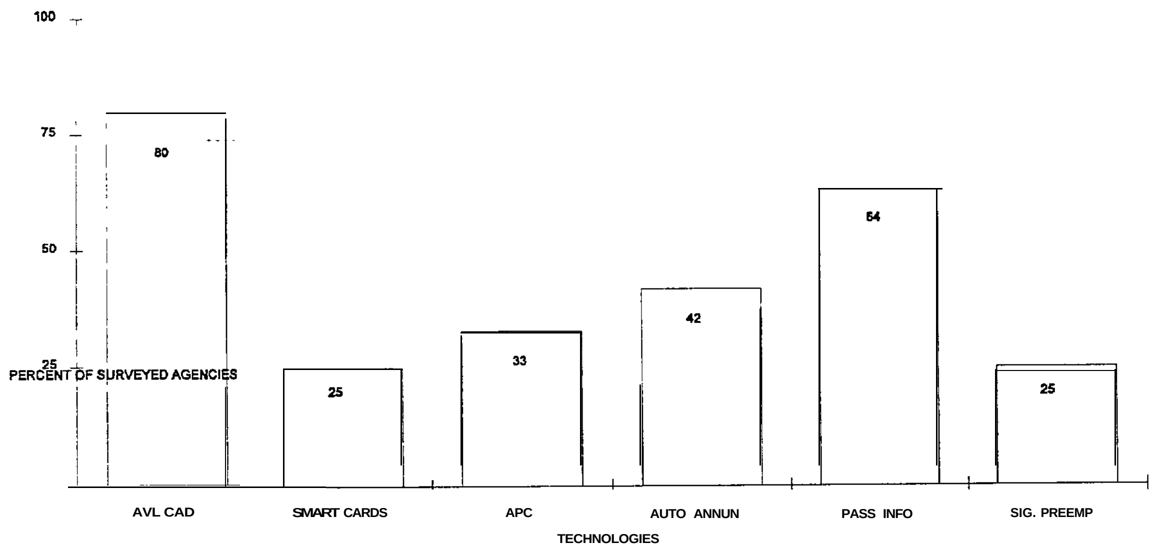
The technologies examined are:

1) Automatic Vehicle Location/Computer-Aided Dispatch
2) Smart Cards (and other multi-use fare media)
3) Automatic Passenger Counters
4) Automatic Annunciation
5) Passenger Information Systems
6) Adaptive Signal Control

2. Deployment

The study found that 94% of the agencies surveyed are deploying or plan in the near future to deploy ITS technologies. The most widely used of these technologies is AVL/CAD as shown in Figure 1. Eighty percent of agencies either have deployed or plan to deploy this system for their fleet. Passenger information systems are the next most widely desired technology.

FIGURE 1
PERCENTAGE OF AGENCIES SURVEYED
THAT HAVE DEPLOYED OR PLAN TO DEPLOY ITS TECHNOLOGIES



2.1 Benefits

Of the six ITS technologies surveyed, only AVL/CAD has been economically justified from an investment viewpoint. Four agencies have provided their analysis and they all have the same basic premise. The use of an AVL/CAD system can provide data to optimize routes reducing run times, and thus utilizing fewer vehicles to serve their route structure.

Kansas City's example of the elimination of 7 buses out of a fleet of 200 by utilizing AVL data is typical. This example shows that the capital savings of $1,575,000 and annual operating savings of $400,000 will amortize the cost of an AVL/CAD system in about two years.

Another benefit of the AVL/CAD system is improved safety. It is clear that in many cities there are daily, major incidents involving buses: drivers being robbed or threatened, buses hijacked, medical emergencies, etc. An AVL/CAD system significantly shortens the time required to respond to these incidents, thus potentially saving lives and resources.

The third measured benefit of AVL/CAD systems is the improvement in on-time performance. Baltimore measured a 23% improvement in overall schedule performance as a result of implementing an AVL/CAD system. Early results from Milwaukee indicate a 28% improvement in schedule adherence.

There are several agencies that have recently installed smart cards in their systems. These are cards developed for the properties' use and in a few cases will be used in parking lots as well. The first use of a commercial smart card will be in Atlanta for the '96 Olympics. Here Visa is issuing both disposable and rechargeable cards through three banks, and the Metropolitan Atlanta Regional Transit Authority (MARTA) will be the initial customers.

All of the smart card users cite operating efficiency as their principal rationale. This efficiency takes several forms: increased revenues, reduced operating and maintenance costs, reduced capital costs, and increased passenger throughput. Although all of the properties are projecting significant cost savings due to these factors, none yet have operating data to verify their projections. However, typical projections are: Ventura County, California estimates \$9.5M/year increased revenue; New York estimates \$98M annual increase in revenue. Seattle is estimating a savings of \$8.5M in reduced maintenance over the life of the equipment; and New Jersey is estimating in annual savings of \$2.7M in reduced labor costs.

Automatic annunciators and passenger counters are used by approximately one-third of the agencies surveyed. They are principally used for ADA compliance and optimization of routes based on passenger loading. Two-thirds of the agencies surveyed are implementing or planning passenger information systems. The systems deployed to date have had good customer response, and are aimed at making transit easier to use by the public. Real time data is the key, and most agencies deploying information systems plan to utilize real time data from their AVL systems.

Adaptive Signal Control is another ITS technology which offers both real productivity improvements as well as improved customer service. By using several techniques, priority at traffic signals is provided to buses, thereby reducing run times on routes. This obviously speeds the passenger trip, but also would allow the route to be served by fewer buses. Conversely, the reduced run times can be used to improve frequency of service.

In Portland a test was conducted on one short route to measure the improved run time. On a two-mile stretch of Powell Boulevard, the run time was improved by between 5% and 8% during peak periods. This is a significant decrease in run time were it extended to a substantial portion of the route system.

3. ITS Technologies

Although there are numerous technologies within the realm of ITS, this study concentrated on 6 categories of ITS technology:

- [] AVL / CAD: Automatic Vehicle Location / Computer Aided Dispatch
- ❑ Smart Cards
- ❑ Automatic Passenger Counters
- [] Automatic Annunciation
- ❑ Passenger Information Systems
- [] Adaptive Signal Control

3.0 Automatic Vehicle Location (AVL) / Computer Aided Dispatch (CAD)

AVL and CAD systems were combined into a single category since they are virtually inseparable. When a decision is made to utilize AVL, it almost always means a new or major upgrade to the dispatch software to take advantage of the special capabilities offered by AVL.

There are several different technologies that have been used to perform the AVL function over the past ten years The-two technologies that dominate AVL implementations are Signpost and GPS. There are a few installations using LORAN C and a few using 'dead reckoning' techniques as the means of determining bus location. However, GPS and Signpost are the dominant techniques and are fundamentally different approaches to position location.

Signpost determines position via a fixed installation of electronic beacons located at various bus stops or other points on the bus routes in the system. When a bus approaches a 'signpost', the bus communicates its identity and perhaps other data to the signpost. The signpost now knows where the bus is, because this system is inherently a short-range communication system (several hundred feet). The signpost then communicates the bus position and other data to the central dispatch computer, usually over a fixed cabled network (e.g. telephone lines). The dispatch computer can now determined the schedule adherence and other data based upon this transmission, and can communicate this back to the bus via the signpost. Often the bus employs a form of 'dead reckoning' to keep track of where it is between signposts.

The use of Global Positioning Satellite (GPS) to determine position location is rapidly becoming the preferred technology. The GPS system is a system of satellites established by the Department of Defense (DOD) to enable very accurate position to be determined anywhere on earth. This system became viable for commercial use just a few years ago. The GPS satellites transmit messages to earth. With a GPS receiver, these messages, which contain an accurate time base, can be received. By comparing the messages from three satellites, an accurate position can be calculated. Because you must be able to "see" three satellites to obtain position, occasionally there can be blockages for short periods of time due to buildings in urban areas. Therefore, most GPS systems also contain a form of 'dead reckoning' to drift through these dead times. Tests have been run in large urban areas, such as New York and Chicago, to demonstrate that these blockages are not a significant problem in tracking the vehicles.

3.2 Smart Cards

The term “Smart Cards” is usually defined as personal debit or credit cards which contain information that can be queried by the card reader and/or information can be added to the card by the reader. This is achieved by the imbedding of an integrated circuit (IC) chip within the card and a reader that can activate the IC to perform multiple functions and contain significant amounts of information.

This study included other fare media that provide multiple uses. The most prevalent of these were magnetic swipe cards, like current credit cards, which are used for bus fares, trains, parking lots, etc. This contrasted with the single-use fare card which is in common use today on mass transit, but which can be used only for a particular transit medium such as the subway, which are not included in the analysis.

3.3 Automatic Passenger Counters

Automatic passenger counters are devices that count passengers getting on and off the bus and which keep track of these counts as a function of time. Thus, they provide a determination of passenger loading along the route. This differs from the fare box count which only provides a count of the number of people entering the bus and total passenger counts per day, or over some time interval.

There are two basic technologies used for passenger counting. A pressure treadle employed at the entrance and exit will count passengers and keep track of these data as a function of time. Another approach is to use a sensor that counts people passing a certain point, usually using infrared as the detection medium.

Both technologies are in limited use and could be integrated with an AVL system as a function of position along a route.

3.4 Automatic Annunciation

Automatic Annunciators provide audio announcement of the next stop, transfer point, etc. Some are integrated with an AVL system which provides the basic cue to the annunciator as to the current location of the vehicle. These can be both audio and visual annunciations, and obviously take the place of the driver having to announce each stop.

3.5 Passenger Information Systems

This category covers a broad range of technologies because there are a wide variety of means of providing information to passengers. However, in this analysis the attempt was to define advanced communicating technologies which provided more than just static data such as a printed schedule. Therefore, technologies such as interactive Kiosks providing real-time data on schedules, were considered. The automation of the telephone information system which allows passengers to obtain route planning information via a Geographic Information Systems (GIS) data base and perhaps real-time schedule information is another technology. It includes a variety of media for communicating real-time data to the riding public.

3.6 Adaptive Signal Control

This technology is a means of employing a degree of control over traffic signals by buses or light rail systems, as they ply their routes. The objective is to provide traffic preference to the vehicle by preempting a traffic signal upon approaching an intersection.

There are two basic approaches used for signal preemption. One employs a special transmitter on the vehicle and a companion receiver at the traffic signal. As the vehicle approaches the signal, the receiver identifies the bus from its transmission and either holds the light on ‘green’ or changes it to ‘green’ for the vehicle.

The other approach is to tie the signal control into an AVL system which has enough accuracy to provide the proper cue to the traffic signal and so provide preference to the vehicle.

4.0 Methodology and Results

This study was conducted by means of a telephone survey covering 36 transit agencies. The agencies surveyed are listed in Appendix I. The agencies were selected from a list of the 100 largest transit bus fleet operators in the United States and Canada. This list covers fleets of nearly 4,000 buses, down to fleets of 100 buses. The first surveys conducted were of the largest bus operators. After querying 18 of these agencies, all of whom had fleets of 800 or more buses, it was decided to examine smaller properties with around 200 buses, in order to evaluate a different segment of the industry. These smaller properties are obviously in smaller cities, thus perhaps influencing both the technology they are deploying, as well as the rationale for deployment.

Therefore, this sample of 36 transit agencies is not a random sample. The statistics cannot automatically be described as representative of the industry. These agencies do represent approximately half of all the buses in fleets greater than 100 buses – 28,000 out of 53,000 – and about one-third of all transit buses in the United States (75,000).

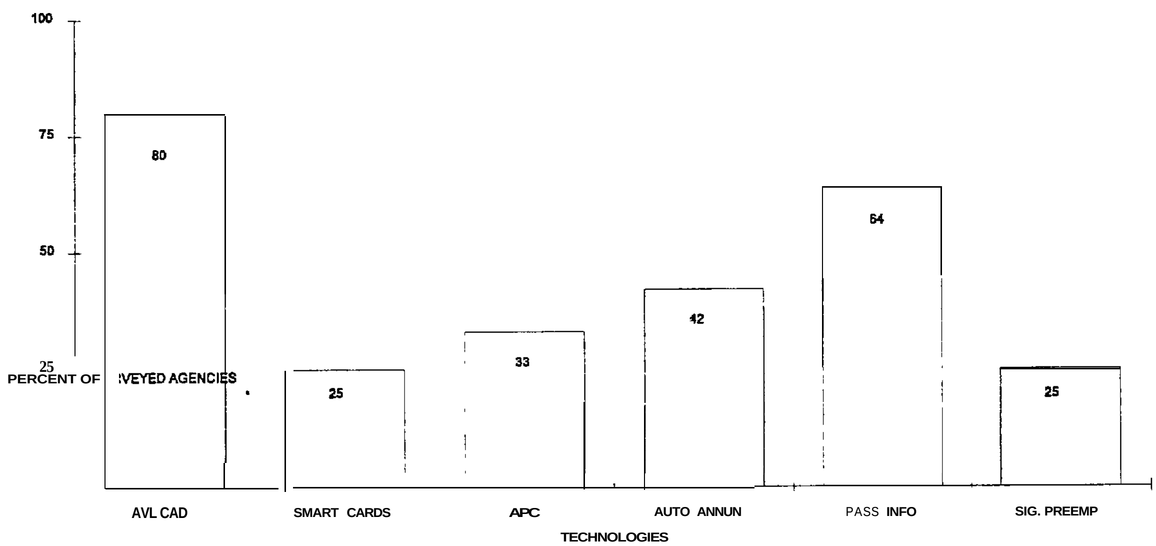
4.1 Status of Deployment

A key question in the analysis is: Do transit agencies perceive enough value in some ITS technologies that they either have procured it or intend to do so in the future. Ninety-four percent (94%) of all the agencies surveyed perceived at least one of the ITS technologies to be of value to their operation. Of these agencies, the desirability of the six ITS technologies is shown in Figure 2.

This shows that the most valued and widely deployed ITS technology is AVL/CAD. This is because AVL/CAD offers the potential for the largest and most visible payoff to the transit agency. From this study and other documentation, there are 25 cities in the United States and Canada which have either deployed or will have deployed AVL/CAD in 1995 — approximately 13,300 buses with this technology. In addition, there are 18 cities which are in the procurement process for AVL/CAD and intend to let contracts in 1995, accounting for another 9,100 vehicles.

The next most widely desired capability is advanced passenger information systems, indicating the need to make transit systems more visible and easier to use by the public. Most transit agencies recognize the advantage of integrating real-time output of an AVL/CAD system into a passenger information system. Further, most of the agencies which are deploying or plan to deploy passenger information systems are utilizing real-time data in

FIGURE 2
PERCENTAGE OF AGENCIES SURVEYED
THAT HAVE DEPLOYED OR PLAN TO DEPLOY ITS TECHNOLOGIES

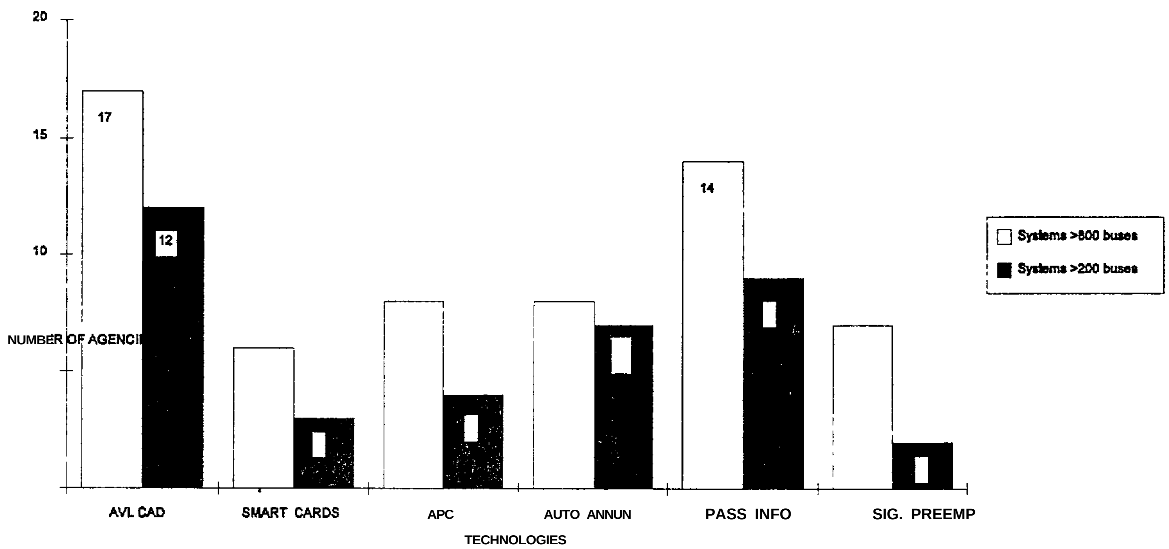


multiple applications, such as an automated telephone information system and interactive Kiosks at malls or major transfer stations.

As might be expected, the larger fleet operations see more value than do smaller operators. Figure 3 shows data for the same criteria in Figure 2, for both large and small fleets having procured or are planning to procure systems. In this Figure, the number of agencies desiring a particular technology is depicted out of a sample size of 18 for both large and small fleets.

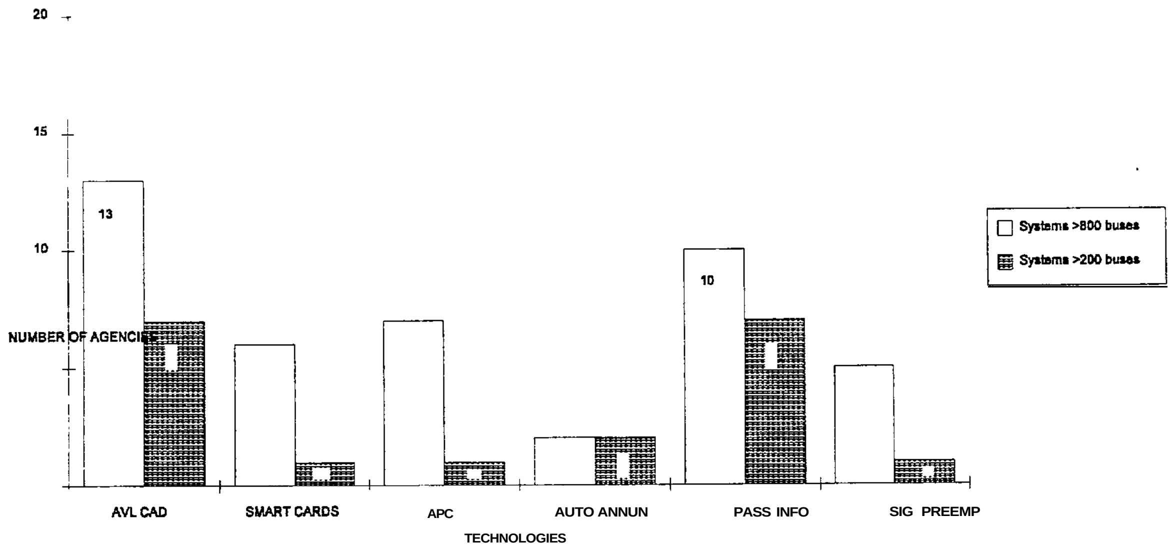
It should be noted that, although the smaller agencies tend to be less active in each technology, the relative importance of each technology is consistent between large and small operations. AVL/CAD is still the number one technology to be utilized, followed by passenger information systems.

FIGURE 3
AGENCIES THAT HAVE DEPLOYED OR PLAN TO DEPLOY
ITS TECHNOLOGIES



To examine deployment, Figure 4 shows the number of agencies which have already deployed; are in the process of deploying; or will complete procurement of ITS technologies in 1995. The relative importance of the various technologies is again fairly consistent with the data in Figures 2 and 3, and in regards to both large and small fleets.

FIGURE 4
AGENCIES THAT HAVE DEPLOYED OR IN PROCUREMENT IN '95 FOR
ITS TECHNOLOGIES



5.0 Benefits of ITS Technologies

The fundamental issue in the deployment of ITS technologies is, why are they being deployed? What benefits do the operators ascribe to these technologies that warrant investing scarce resources? The benefits of each technology vary widely. However, there are some common features throughout:

- Improved customer service
- Improved productivity of either their fleets or their people

However, there are few documented results showing quantifiable benefits to the deployment of ITS technologies. In examining the benefits, each technology will be treated separately.

5.1 Benefits of AVL/CAD

In the use of AVL/CAD there were three basic benefits which rank almost equal among the agencies procuring or planning to procure a system. These are:

- Schedule adherence
- Safety
- Productivity

5.1.1 Schedule Adherence

It is widely accepted that the ability of an AVL/CAD system to keep track of all vehicle locations and compare that to the scheduled route time allows a dispatcher to manage the fleet more effectively in keeping buses on schedule.

In 1991, the Baltimore Mass Transit Administration (MTA) ran a controlled test on two of their longer routes, 20 miles and 28 miles, using AVL-equipped buses and standard buses. The results of these tests demonstrated a 23% increase in on-time performance on these two routes. This improvement in schedule adherence is a key factor in the confidence the public has in the transit system. Improved customer service is a major element in virtually every transit agency's rationale for deploying almost all ITS technologies.

The Kansas City, Missouri transit system undertook a concentrated effort to improve on-time performance. This effort lasted for three years, 1986-1989, and on-time performance was improved by approximately 7%. After installing an AVL system, Kansas City transit systems improved schedule adherence by another 12% within the first year of operation.

Recent preliminary data from Milwaukee has shown a 28% decrease in the number of "late" buses. "Late" is defined as more than one minute behind schedule. (Milwaukee was not in the original survey.)

5.1.2 Safety

Safety is a major factor in deploying an AVL system. However, there are several facets to the safety issue. There is the safety of the passengers on the bus; the safety of those waiting for a bus; and the safety of the driver. Several agencies regarded safety to be such a crucial issue that they justified the purchase of an AVL/CAD system solely on the basis of safety. This degree of safety consciousness is driven by the fact that in all large cities and in many smaller cities, there are significant incidents on their buses every day. These incidents can be attempted robbery of the driver; a medical emergency involving a passenger; an altercation among passengers; etc. In all of these incidents, it is important to be able to evaluate and provide the appropriate emergency service, whether it be police or medical assistance.

A fundamental feature of virtually all AVL/CAD systems is a 'silent' alarm capability. Typically the driver will depress a covert alarm button. This flashes on the dispatcher's display immediately, taking priority over other activity. The dispatcher can activate a covert microphone on the bus and listen to what is happening. Based on this assessment, he then notifies the appropriate emergency service and tells them the exact location of the bus. These features enable a response without all participants in the bus emergency knowing that help is on the way, or that the driver has alerted anyone.

The result of this capability has been described in a number of ways in terms of the realized benefits:

- Some agencies quote a 40% reduction in the time required to respond to an incident.
- One city had the dispatchers estimate the response time to an emergency. Dispatchers estimated 7 to 15 minutes' response time without AVL and 3 to 4 minutes' response time with AVL.
- One agency said that before AVL, they would call the police, telling them where the bus should be. The police would look along the route for 5 to 10 minutes before finding the bus. Now, with AVL, they know exactly where the bus is and the police are on the scene in one to two minutes.
- Another agency said they had difficulty getting the police to respond to their calls, because the police often could not find the bus and had grown frustrated with their inability to help.
- Several agencies indicated that their customers were afraid to wait at bus stops for uncertain periods. With AVL's ability to improve on-time performance and the ability to integrate it with the Telephone Information System that allows customers to call and get real-time status, they felt that AVL would be a major benefit to safety as perceived by their customers.

5.1.3 Productivity

The improvement of productivity in transit operations is readily amenable to quantification. Of the agencies surveyed to date, several have provided the economic justification for the procurement of AVL/CAD systems. However, only two instances of measured improvements in productivity have been found.

The economic justification for AVL/CAD centers on two principal factors:

- Elimination of people currently monitoring schedule performance
- Reduction in the number of buses required to provide service

Some agencies currently employ people to randomly sample the schedule performance of their fleets. In one city, the agency planned to eliminate this function entirely, eliminating the cost of about thirty personnel, or approximately $1.5 million per year, which would amortize the cost of AVL in 2 to 3 years. Larger cities tend to have people engaged in checking schedules. However, in the smaller properties, no one indicated they had people devoted to this task. Rather, the supervisory personnel would perform spot checks as part of their duties.

Therefore, the improvement of productivity through the use of fewer vehicles appears to be the most widely applicable justification. The reduction in the number of vehicles is a result of a detailed analysis of the data provided by an AVL/CAD system. The AVL/CAD system provides detailed run times, at all times of the day, for extended periods of time. When you combine this data with fare box data, as to revenue per stop, it is now possible to do a more optimal distribution of vehicles serving the routes.

Most properties did not believe they would improve utilization of their vehicles. This is because they believe their schedules are as good as they can be. Yet two cities have actually reduced the number of vehicles used to serve their routes after a detailed analysis of AVL data. Kansas City was able to reduce the number of buses serving their routes by 7 vehicles out of a fleet of 200. This reduction was achieved by Scheduling Superintendent, Delores Brehm who analyzed scheduled run times and recovery times. This is made feasible because AVL/CAD provides a virtually unlimited number of observations of actual travel times, because buses are tracked from time point to time point. To perform this analysis, Superintendent Brehm used the segment running times from the AVL data for the previous 6 months. The KCATA schedulers discovered that a reduction in running time could be made on several routes such that the number of buses required was less than current schedules. In some cases, the savings involved base buses (operating the entire day), and in others, the savings were limited to buses operating only at peak periods.

These results produced a 3.5% reduction in vehicles required. Whether an agency decides to use this savings to reduce expenses or expand service is a decision their management must make themselves.

Another agency which has over 1,000 buses has achieved efficiencies of 4% reduction in fleet size as a result of operating with an AVL/CAD system. A study by the National Urban Transit Institute[1] concluded that an AVL/CAD system must reduce fleet size by 2.3% to break even. However, a number of agencies have projected savings of 4% to 9%, varying because of individual circumstances.

The Kansas City analysis provides a clear example of this productivity enhancement:

<u>Reduce Fleet by 7 buses</u>:

Capital Expense:	$225,000/bus	$1,575,000
Maintenance Expense:	$ 27,000/bus/year	$ 189,000/year
Total Labor:		$ 215,000/year

Because Kansas City spent approximately $2.3 million for AVL/CAD and a new communications system, it is clear that by saving $1.5 million in capital by not replacing buses, and $400,000 per year in operating expenses, that the investment is amortized in about two years. In addition, the operating expense savings will continue on an annual basis,

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[1] ***Economic and Policy Considerations of Advanced Public Transportation Systems, Oct.*** 1994, National Urban Transit Institute

making the AVL/CAD a good investment. Again, it must be noted that these savings are not automatic. The agency must effectively utilize this new tool to realize the efficiencies inherent in the technology.

Analyses by three other agencies project a reduction in fleet size from 2% to 5% because of the efficiencies of bus utilization. In addition, they project savings in street personnel, which again produces an amortization of the investment in two to three years.

Another result of an AVL/CAD system is a major reduction in the amount of voice traffic on the communication system. Because most of the voice traffic is a result of reporting to the dispatcher, an AVL/CAD system eliminates most of this voice traffic. One agency experienced a 40% decrease in voice communication with the dispatcher. This frees the dispatcher to concentrate on managing his routes and on responding to incidents. It also frees very valuable frequency allocations which are usually at a premium in any metropolitan area.

Most agencies recognize the need to provide accurate real-time information to the riding public and to make it easier to use public transit. AVL/CAD systems provide the basic data on schedule adherence which is fundamental to these passenger information systems. Although none of the agencies surveyed are projecting a definite increase in ridership because of better schedules, improved communication with customers, or improved safety, most of the properties expect to achieve either an increase in ridership or a reduction in the decline of ridership. Other benefits cited are:

- The AVL processor on the bus can be interfaced with existing vehicle monitoring equipment to directly report on vehicle condition. This can reduce the number of major equipment breakdowns by reporting potential problems before serious damage occurs.
- Capital cost for other functional capabilities such as automatic annunciators can be reduced by interfacing AVL and the annunciator.
- AVL permits improved real-time monitoring, which ensures that connections with other bus routes or other modes of transportation are made with minimum delay time.
- AVL provides an automated record of driver performance which can be utilized to interface with payroll and other administrative functions to reduce the cost of personnel administration.

5.2 Benefits of Smart Cards

Since the initial survey was conducted, there has been considerable activity in smart cards in general, and in the transit agencies specifically.

In the original survey, only nine (9) of the agencies surveyed are deploying or plan to deploy this fare card technology, and all but one are deploying systems which use magnetic swipe cards. Of these 9 agencies, 7 are either deployed now or will be deployed in 1995, and 6 of the 7 are in large fleet properties. There are now 4 more cities deploying smart cards, Ventura County, California; New Jersey Transit; Seattle Metro; and Atlanta Regional Transportation.

The benefits cited for smart cards are:

- Customer Service
- Operating Efficiency

5.2.1 Customer Service

Most agencies recognize that an impediment to utilizing public transit is that it is difficult to use. A key benefit of smart cards is their ease of use and the ability to use them for a variety of purchases, not just transit. For instance, in Atlanta the first broad application of a commercial smart card is being implemented by VISA. This card will be able to be used at all MARTA rail stations instead of cash. Most importantly, VISA has signed up a number of commercial establishments to use the card. It is being issued to all account holders by three major banks and is expected to be in wide circulation by the summer of ‘96, in time for the Olympics. MARTA passengers will be able to use the card for numerous purchases, not just transportation. This card is a disposable card, issuable in amounts of $10, $20, $50, and $100. Thus, using public transit can now be just like making any other purchase. VISA is expected to introduce a rechargeable card in the near future.

Another feature of smart cards that enhance customer service is the ability to eliminate transfers making it easier to use the transit system as well as saving transfer expenses for the transit operator. This is especially valuable to the physically challenged customer.

5.2.2 Operating Efficiency

There are three major facets of improved operating efficiency attributable to smart cards; increased passenger throughput, increased revenues, and reduced operating and maintenance costs.

Current smart cards are “contact” cards, requiring the passenger to insert or hold up against a reader. However, this process of paying for fares by deducting the appropriate amount from the card is substantially less time-consuming than a cash transaction. Therefore, it is expected that significant improvement in run times can be achieved. As with other technologies that improve run time, (AVL and Adaptive Signal Control) this provides two major benefits. It makes the trip faster for the passenger, a critical issue when trying to expand the transit customer base. In addition, it offers the opportunity to operate the routes with fewer vehicles while retaining the service level, or to increase the frequency of service without additions to the fleet.

There are a variety of opportunities to increase revenues using smart card technology. Only one agency has thus fare reported a revenue increase. New Jersey transit reported a 12% increase in revenues since the inception of its smart card project. Other agencies all predict an increase in revenues for a variety of reasons.

The reduction of fare evasion and short-changing can be a major revenue enhancement. For example, Ventura County, California projects a savings up to $9.5M per year due to this factor alone. New York estimates an additional $25M annual revenue increase in conjunction with a new turnstile design due to reduced transfer theft and misuse.

Increased revenues are projected from a number of other attributes of smart cards. The smart card will produce revenues to the transit agencies from selling the cards. This revenue derives from interest on the "float" or unused portion of the card. The transit agency retains the total value of the card until it is actually used. New York estimates a revenue gain of $34M from the float, merchant fees, and enhanced marketing. Another facet of this technology is that current experience in Europe suggests that about 1% of the cards value never gets used. For New York this would be $140M per year in revenues.

Other potential revenue enhancers are, revenues from advertising on cards, and cards purchased by collectors. Interestingly, Paris Metro reports that up to 20% of some cards appear to be purchased by collectors.

A key facet to potential revenue enhancement is the significant pricing flexibility offered by smart cards. The ability to price service to match demand and customer needs can be a major factor in improving ridership and maximizing revenue from existing service.

Another facet of improved operating efficiencies is the reduction in costs due to maintenance and handling cash. In Seattle, they have estimated a life cycle cost reduction of $8.5M from reduced maintenance costs. The handling of cash is a significant expense at all transit agencies. The smart card can significantly reduce these costs. For example, New Jersey transit has estimated a savings of $2.7M annually from the cost of handling cash. Similarly, Atlanta has estimated a $2M savings in this area.

All in all, smart cards offer a wide variety of operating efficiencies. This is especially true if the card is a commercial bank card, not unique to the transit operation. For instance, in Atlanta all the card readers are provided by VISA to MARTA, and cards are issued widely for uses other than transit expanding their acceptance.

5.3 Benefits of Automatic Passenger Counters (APC)

This technology is widely accepted as having value in the management of the system. However, most agencies are skeptical as to its accuracy. Minneapolis ran a test of its APC by cross-checking its count with the fare box, and by placing checkers on buses to manually count passengers. Their test produced a 98% correlation between the three methodologies.

Passenger counters are generally being deployed on a portion of the fleet, usually 25% to 33%. This allows the property to move these vehicles around their routes to check passenger loads. Some agencies keep buses equipped with APC's on the heavily-utilized routes to permit replanning of the routes and schedules.

The benefit of APC's is self-evident. They allow accurate passenger counts, which enable the optimum utilization of vehicles based on passenger loads. Of course, they also greatly increase the accuracy of the agencies' required DOT reports.

5.4 Benefits of Automatic Annunciation

Automatic Annunciators are receiving significant attention because of ADA requirements on public transit. Among the 40% of surveyed properties deploying or planning to deploy annunciators, the distribution is about equal between large and small fleets.

Some agencies are planning to procure annunciators as part of, or as an adjunct to, the procurement of AVL. AVL is the obvious technology into which annunciators should be integrated.

About half of those agencies planning to buy annunciators are doing so to relieve the driver of the burden of announcing stops. "The driver needs to pay attention to driving" is the comment made. The other half are procuring annunciators because they feel ADA requirements are demanding it. They receive complaints that the drivers don't announce stops or they can't be understood. Thus, they feel they must deploy annunciators. "By the way, it will allow the drivers to pay more attention to driving."

5.5 Benefits of Passenger Information Systems

Passenger information systems are widely accepted as a necessity in today's world of convenient information. About two-thirds of all agencies surveyed planned some activity in passenger information. Virtually all of them plan to include real-time data.

There are three dominant means being implemented or planned for disseminating data. First is the Telephone Information Center (TIC). Most operators plan to automate much of the TIC via a GIS data base for route planning. In addition, several properties are tieing the data from the AVL system into the TIC, so that operators can provide current schedule status on their buses. The second most popular means of disseminating information is signage at major transfer points and stations. This signage may take many forms, but most want real-time data on arrivals and departures. Third is the use of Kiosks, which are widely used to disseminate data. Most of these are interactive where the customer may call up the data that is desired. Also, they usually contain more than transit data – some have intermodal data, tourist information, ride sharing and other public service information, The Kiosks are placed at locations where they may serve large numbers of potential customers, such as major office complexes, shopping malls and transportation centers.

Several agencies have conducted surveys of customers and potential customers. Their findings are consistent; the single-most common reason for not using transit is it is difficult to use: schedules are hard to get and to read, and the information is not reliable.

The expansion in passenger information is a direct result of this concern on the part of the public.

The Los Angeles Smart Traveler project recently conducted a survey of the public's response to Kiosks as a means of obtaining travel information. Their results are:

- [] 79% found the Kiosks easy to use; only 5% found them difficult
- [] 84% indicated they would use them again
- [] 86% would encourage others to use them

Although it is widely accepted that advanced passenger information systems are desirable – even necessary – no agency has projected an increase in ridership as a result of this technology. Rather, they feel it is necessary just to be competitive with other modes in todav's information-rich environment.

5.6 Benefits of Adaptive Signal Control

In general, the only cities deploying or contemplating the use of signal preemption are the larger metropolitan areas. However, it is noteworthy that their rationale for signal preemption could well apply to most transit properties.

One major city plans to utilize signal preemption along with AVL/CAD. The signal control is planned for its longer routes extending into suburban communities. They expect the signal preemption to significantly reduce run times, and thus allow them to serve these routes with fewer buses while retaining frequency of service. This, of course, is a significant cost savings, and if implemented might well offset the cost of signal preemption – especially when integrated with AVLICAD. However, the city has not done an analysis to show these economic benefits.

The other rationale for signal preemption is customer service and competitiveness. One city cited the time to come into town on a bus from suburbia is twice the time of a private car. Therefore, if they expect to compete with the private automobile, they have to use signal preemptionto shorten the trip time on the bus. Of course, this can produce exactly the same effect as the rationale above – require fewer buses to serve that route. However, customer service is at the heart of this benefit, and is driving cities to offer some preferential treatment to multiple occupant vehicles.

Signal preemption is the one technology which provoked a number of these responses:

- [] "The traffic engineers would never go along with that."
- [] "The people here would not allow us to interfere with driving."
- [] "We sure should do that, but it would be a heck of a battle."

In spite of these attitudes, it is clear that there is significant benefit to using adaptive signal control. Portland offers the only known quantification of this benefit.

Portland undertook a project to evaluate two difficult adaptive strategies and two different bus detection technologies. [2] The project implemented the two strategies along a 2-mile section of Powell Boulevard, a major artery in Portland. The first approach was to extend the "green" cycle for a bus approaching an intersection, and an early return to green when a bus is already at the intersection. Another strategy was employed when buses had a right bus lane or a right-turn-only lane. Here, the bus was given a special advance green light to effectively give the bus priority in reentering the traffic flow - it was called a "queue jump."

The result of this project showed a decrease in bus travel times of between 5% and 8% during peak travel times. Equally important, from a passenger standpoint, the computed person delays decreased by 12% with the bus priority system. These results clearly demonstrate the potential operating efficiency of adaptive signal control. A 5% decrease in run time is significant for major high density routes where service frequency is the highest and a significant portion of the fleet is utilized. These savings can be used to increase service frequency or operate the route with fewer vehicles.

The Portland project did not have the benefit of having an AVL system on its fleet. Thus, it implemented a special system to communicate to the signal system. However, with AVL equipped buses, a more cost-effective implementation can be implemented. In either case, it is clear that an Adaptive Signal Control system is a good financial investment, as well as providing improved customer service.

6.0 Conclusion

It is clear from this survey and analysis that a key building block to improved transit operations and service is an AVL/CAD system. Not only can this investment produce excellent financial returns, but it is crucial to the implementation of several other advanced technologies. Clearly, passenger information systems that offer real-time data to customers is a major advantage and relies on AVL data. Similarly, automatic passenger counties when tied into bus position from AVL offer the biggest potential opportunity to optimize the fleet utilization based on demand. Automatic annunciators too, are a natural extension of the knowledge of bus position. Finally, adaptive signal controls may be more easily implemented when coupled with the AVL system to cue the traffic signal system.

It is also clear that the implementation of these technologies offer two major benefits:

- Operating Efficiencies
- Improved Customer Service

and are good economic investments in an era of doing more with less.

Finally, as operators look to other strategies to expand their customer base in the future, these technologies are fundamental building blocks. One strategy cited frequently is

2 Bus Priority at Traffic Signals in Portland; William C Kloos. Alan R Danaker & Katherine M Hunter-Zaworski. ITS America 5th Annual Conference. March 1995

the use of route deviation - when a bus is allowed to deviate from its route to service passengers based on demand. Several agencies are now experimenting with this approach. It is clear, that to provide control of this dynamic process, one has to know there the buses are and their load in real time. Also, once a bus deviates from a route, adoptive signal control can allow the bus to regain some or all of the schedule time lost in the deviation.

APPENDIX 1. Cities Surveyed

City	***Number of Vehicles***	***City***	***Number of Vehicles***
Baltimore, Maryland	850	Akron, Ohio	180
Vancouver, BC (BC Transit)	950	Beaver County, Pennsylvania	36
Boston, Massachusetts	1,014	Ft. Lauderdale, Florida	200
Chicago, Illinois	2,080	El Paso, Texas	210
Dallas, Texas	1,280	Indianapolis, Indiana	157
Denver, Colorado	854	Jacksonville, Florida	160
Houston, Texas	1,240	Kansas City, Missouri	200
Los Angeles County, California	2,508	Madison, Wisconsin	180
Minneapolis, Minnesota	980	Hampton, Virginia	125
Newark, New Jersey	2,922	Richmond, Virginia	182
New York City, New York	3,670	Albuquerque, New Mexico	200
Ottawa, Canada	800	Tacoma, Washington	203
Suburban Chicago (PACE), Illinois	913	Tampa, Florida	167
Philadelphia, Pennsylvania	1,550	Syracuse, New York	192
San Francisco, California	850	Norfolk, Virginia	180
Seattle, Washington	1,100	Toledo, Ohio	200
Washington, DC	1,450		