

Montachusett Area Regional Transit Authority
(MART) Automatic Vehicle Location and
Mobile Data Terminal (AVL/MDT)
Pilot Program Report

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Preface

This report presents a project overview, challenges and lessons learned for implementation of ITS technologies at the Montachusett Area Regional Transit Authority (MART).

In completing the assessment, we reviewed the planning, procurement, and implementation process used in completing the AVL/MDT pilot program.

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1 Acronyms

ADA	American with Disabilities Act
AVL	Automatic Vehicle Location
CAD	Computer Aided Dispatch
CDMA	Code Division Multiple Access
CDPD	Cellular Digital Packet Data
DOT	Department of Transportation
DSRC	Dedicated Short Range Communications
FTA	Federal Transit Authority Administration
ITS	Intelligent Transportation System
MART	Montachusett Area Regional Transit Authority
MDT	Mobile Data Terminal
MPO	Metropolitan Project Office
NTCIP	National Transportation Communications for Intelligent Transportation Systems Protocol
RF	Radio Frequency
TCIP	Transit Communications Interface Profiles

2 Executive Summary

In August 2000, the Montachusett Area Regional Transit Authority (MART) received a grant from the Federal Transit Administration (FTA) to deploy a pilot program for an Automatic Vehicle Location (AVL)/Mobile Data Terminal (MDT) (AVL/MDT) system and to integrate this system with their existing reservation and dispatch system. The goal of the project was to support MART's ITS objective of enhanced and expanded transportation and transit mobility. MART was assisted with contractor program management support to extend their internal staffing to address the specific needs of this project.

A structured procurement and implementation process was initiated with the following major tasks:

- ⇒ Requirements Assessment and Statement of Needs
- ⇒ ITS Technology assessment
- ⇒ Procurement Plan
- ⇒ Deployment Alternatives Analysis
- ⇒ Specifications Development
- ⇒ Procurement
- ⇒ Design and Implementation
- ⇒ Test
- ⇒ Training
- ⇒ Operations Planning
- ⇒ Maintenance and Warranty

The program included procurement of a new AVL/MDT system and the upgrade of the existing MART dispatch and reservation system to provide a compatible interface.

MART began their project in August 2000 with the hiring of a consultant to assist in planning and executing their ITS program. The consultant was responsible for the engineering analysis, design, procurement package and overall management of the deployment of the AVL/MDT system and integration of the new technology with the legacy reservation and dispatch system.

In December 2001, MART initiated, through competitive procurement, a contract for 15 AVL/MDT systems and issued a contract modification to an existing contract to upgrade the reservation and dispatch systems. Integration of the two systems and conducting formal system testing proved the most technical challenge for the program. A significant portion of the existing reservation and dispatch system was proprietary and lacked system documentation. Taking advantage of the enhancement initiative, MART was able to upgrade documentation of the existing reservation and dispatch systems, as well as obtain proper documentation for the new AVL/MDT systems. Obtaining these documents are critical to MART as they move forward with continuation of their ITS program with the addition of more AVL/MDT systems.

After installation, integration, informal testing and training, MART completed the formal testing program in three months. MART commissioned their system in November 2002 with an initial fleet of 15 vehicles equipped with an AVL/MDT system, 4 AVL Tracking workstations, and an upgraded reservation and dispatching system. The total pilot program, beginning with assessment of the agency requirements through deployment and commissioning of the new and upgraded systems, took 27 months.

MART's existing communications system was found inadequate in supporting the new ITS technology. Upgrading the existing communications system to support the pilot program was cost-prohibitive. After investigating alternative technologies, the program chose to implement the use of a commercial communications technology available in the service region. During testing, it was noted the commercial communications service was not as reliable as planned. MART may review newer commercial communications technologies (e.g., CDMA-2000), as they become available in the service region.

No systems that included the National Transportation Communications for Intelligent Transportation Systems Protocol (NTCIP) Transit Communications Interface Profile (TCIP) standards as part of the off the shelf system were proposed during the solicitation process. Because use of the TCIP standard was not required by the FTA, the TCIP standard was not yet complete, and the program comprised only 15 systems, MART did not require the bidders to upgrade their systems to support the procurement.

Planning the agencies' operational concept was and remains the most critical single challenge for MART. Because the pilot program was deployed on less than 10% of MART's fleet, there is a need to operate in "cut-over" mode - maintaining the old operational procedures, while melding new operational procedures into the daily operations. This has resulted in increased workload for the dispatchers. The requirements assessment for the dispatch and reservation system was developed with limited user input, which resulted in limiting the realization of the full benefit of the new technology to cut processing time for reservations and enable quick changes in driver assignments. Acceptance and use of the new technology is critical to realize MART's ITS program goals. As they increase the presence of the new technology with additional systems, the differences in operational procedures will converge and the workload will lighten.

3 Background

MART was established in 1978 to provide public transportation to the 18 Massachusetts communities of:

Fitchburg	Ashby
Leominster	Lunenburg
Gardner	Shirley
Royalston	Ayer
Templeton	Littleton
Winchendon	Lancaster
Hubbardston	Sterling
Westminster	Hardwick
Ashburnham	Harvard

MART contracts its fixed-route and paratransit services through a variety of contractors from its headquarters at R1427 Water Street, Fitchburg, Massachusetts. MART fixed-route service operates with 26 buses. Its paratransit services are more extensive, and operate throughout Eastern Massachusetts with approximately 120 vans, minivans, and station wagons. The paratransit services are provided as a complementary service to MART's fixed-route bus operation, in compliance with the American with Disabilities Act (ADA) requirements. In addition, MART serves a variety of clients in eastern Massachusetts, including Councils on Aging, Welfare to Work programs, and veteran's organizations. Approximately 3,500 trips are made on MART's service network daily.

MART's dispatchers communicate with their drivers over a 453.8 MHz radio system with area coverage provided by two radio towers. The radio towers, which are leased by MART and are located on Alpine Hill in Fitchburg and Reservoir Hill in Gardner, provide limited coverage. To fill the dark territory areas, MART also uses a commercial cell phone system to supplement the 453.8 MHz radio network; however, there are still coverage problems with both systems.

MART uses a proprietary Oracle-based computerized booking program to deploy demand response services for approximately three to four thousand trips daily in the 18 communities in Eastern Massachusetts comprising the MART service area. Prior to the pilot program, trips were booked 24 hours in advance by reservation specialists, and trips were manually assigned to drivers 12 hours ahead by the dispatchers. Without the AVL technology, it took 6 to 8 man-hours daily to manually sort and schedule the next day's runs.

All MART dispatchers except two are located in Fitchburg. The other dispatchers are at Gardner, MA. Gardner uses the same computer software and operating practices, as does Fitchburg. Each facility uses different third party transportation service companies.

The need for transit in the primarily rural areas serviced by MART is significant. Even though the MART residential service area provides urban area work force for the cities of Worcester and Boston, there is little availability of traveler information. Geographically, the MART service area is comprised of hilly terrain and presents daily difficulties in maintaining continuous and reliable radio communications with their vehicle operators. Since this negates the ability to do real-time dispatching, all trips are booked 24 hours in advance.

The Requirements Assessment and Statement of Needs documented the following constraints limiting the ability for MART to expand service to meet increasing customer demands:

- The need for transportation in MART's service area exceeded their current capability, based on the fact that there are a limited number of vehicles.
- RF coverage, provided by the existing communications infrastructure, is insufficient. Communications with drivers and, subsequently, knowledge of vehicle location was intermittent.
- Demand-response service must always be scheduled 24 hours ahead of time.

To address these constraints, MART designed an ITS pilot program with the following goals:

- Reduce the 24-hour lead time for booking trips, and provide more flexible and tighter schedules to accommodate additional passengers.
- Reliable communications with the knowledge of where their drivers are at all times. This will improve operational efficiency and increase driver and customer safety.
- Record scheduling data and generate reports to further analyze service in order to better schedule, route, and manage operations.

4 Project Overview

In August 2000, the Montachusett Regional Transit Authority received a grant from Federal Transit Administration (FTA) to deploy a pilot program for a Computer Aided Dispatch (CAD)/Automatic Vehicle Location (AVL) system and to integrate this system with an existing reservation and dispatch system. MART was assisted with contractor program management support to extend their internal staffing to address the specific needs of this project.

A structured procurement process was initiated with the following major tasks:

1. Requirements Assessment and Statement of Needs:

An assessment of current systems supporting the transit agency operations, MART's operational concept, and MART's current service delivery and service projections were documented. This assessment formed a basis for a requirement analysis statement.

2. ITS Technology assessment:

Using the Requirements analysis, MART and their consultant conducted a technology assessment to determine available technologies that would meet their requirements needs. Several vendor systems were reviewed and vendors were invited to present their off-the-shelf technology for MART.

3. Procurement Plan:

A procurement plan to document alternatives to address MART's Statement of Needs was discussed. Competitive procurement for the AVL system, use of a commercial communications system to support data communications, and an upgrade of the existing reservation and dispatch systems were approved. Options for enhancements such as mobile data terminals, and addition of AVL/MDT units to the fleet were included in the planning providing a building base from which MART could expand their ITS infrastructure.

4. Deployment Alternatives Analysis:

Several technology options were reviewed prior to development of the system specifications to support the procurement for an AVL/MDT system. The alternatives concentrated on the requirement for data communications. Based on the limitations of the pilot program, it was determined the existing radio system would not support the data communication requirements of the AVL/MDT systems. Additionally, the cost to deploy a new radio system was prohibitive. The alternative technology of Cellular Digital Packet Data (CDPD) was available in the region from a commercial carrier and was selected for use in the pilot program.

5. Specifications Development:

Performance based specifications were developed for the AVL/MDT systems. Performance specifications were chosen over design specifications to support the fast changing technology used as a basis for many of the commercial ITS systems sold today.

6. Procurement:

A procurement package was prepared to solicit proposals for an AVL/MDT system, including control center-based vehicle tracking software to supplement dispatchers, communications package, training, maintenance and warranty.

7. Design and Implementation

Procurement of the AVL/MDT systems was implemented based on a requirements analysis, specification, and procurement process. The system provider was required to submit designs, implementation and test programs, and an associated training package. The legacy dispatch and reservation system was upgraded under a separate contract. A total of 15 systems were installed and tested.

8. Test

Both informal and formal testing were conducted. A test plan was prepared for each system as well as for integration testing between the AVL/MDT and reservation and dispatch systems. MART placed both systems under configuration control during formal testing forming a basis for analysis as testing progressed.

9. Training

Operations and Maintenance training included both the AVL/MDT and the reservation and dispatch systems. Training packages were developed to support initial refresher training and training of new employees. The initial training program was held 3 times in order to facilitate the third party operator staff scheduling.

10. Operations Planning

MART faced a situation where only a small portion of their fleet was equipped with the new ITS technology while the majority of the fleet remained operating with the existing systems. Operations planning needed to address the mix of systems in the field, along with staffing requirements.

11. Maintenance and Warranty

MART procured a warranty and maintenance contract and options with the contract for the pilot program, AVL/MDT systems, and associated control center hardware and software. Spares and replacement of systems along with on-call technical support is covered under contracts with the system vendors. Personnel from MART's Management Information System group received training to enable

the agency to administer the system, remove and replace MDTs, and test various functions of the MDTs and gateway server.

MART's AVL/MDT pilot program was completed 6 months over schedule but remained within budget. MART is planning to expand the ITS program with the addition of more AVL/MDT systems to their fleet.

5 Consistency with the National ITS Architecture

To meet FTA policy guidelines for consistency with the National ITS Architecture, MART implemented their project consistent with a system engineering process. The project implemented off the shelf AVL/MDT systems and enhanced existing proprietary reservation systems; therefore, it did not implement the TCIP Standard. There is currently no Regional ITS Architecture for Central and Western Massachusetts. To comply with FTA policy, MART plans to use their experience from this project to support the Metropolitan Project Office (MPO) in development of a Regional ITS Architecture within the next few years.

6 Project Challenges

There were several challenges faced in planning for and implementing the MART project keeping with the requirement to support the National ITS Architecture and ITS Standards. The following section summarizes challenges faced and how they were addressed in the MART program.

- Standards: FTA has issued a policy recommending use of ITS Standards, and requiring use of only US DOT approved standards. At the start of the MART program, only one ITS Standard had achieved US DOT approval. This standard, Dedicated Short Range Communications (DSRC) was not appropriate for the systems being planned for in the MART program. MART faced the dilemma of how to address the FTA requirement given the current status of the transit standards. Considerations influencing MART's decision to accept a standard capable system (only if offered as part of the vendors current capability but not to require off the shelf system modifications to implement the available standards) were:
 - No systems with ITS Standards were presented during the technology reviews nor offered during the procurement cycle. Since the program was a pilot program impacting a small portion of the fleet, 15 out of 140 vehicles, customizing a system to incorporate ITS Standards was not supported.
 - There is no testing guidance for compliance with the approved ITS TCIP standard, leaving an open issue regarding validation of system compliance once installed.
 - The transit standards were only partially complete at the time the MART program was in procurement.

- Institutional: MART delivers paratransit and non-revenue transit services using multiple third party operators operating from two garages. Contract terms and support from these companies and unions needed to be coordinated to assure successful use of the new ITS technology.
 - MART held several meetings with their transportation service provider companies to apprise them of the pending new systems being installed in the service vehicles and control center.
 - The service provider companies were invited to attend program meetings and briefings that enabled them to become familiar with the program, its goals, and the technologies being deployed.
 - Service provider staff was included in interviews early in the project to collect and document their stated needs and ideas regarding issues, system constraints, and ideas for new technologies to enhance their job performance.
 - Training was organized in multiple sessions to accommodate staff planning and driver work shifts.
 - Training systems were made available for periodic driver refresher training.
 - The transportation service providers were included in development of revised operations procedures to accommodate successful use of the mix of new and old technologies.

- Institutional: MART's existing reservation and dispatch system was comprised of customized and proprietary software. The software was not well documented, and no configuration control document was available. Furthermore, requirements for the system upgrade were not documented nor was a structured engineering process implemented to guide the upgrade of the legacy system. As such, it was difficult to establish the integration and formal system test programs.

- Institutional: Consistency with the National ITS Architecture for transit agencies remains an unclear task. The National ITS Architecture provides details specific to transit industry in only two areas: vehicle and center. Standards appropriate for the transit industry to support the architecture, notably the TCIP standard, have yet to be completed. Many vendors are investing in XML technologies rather than the ASN.1 technology prescribed by the current sections of TCIP which have been completed. As such, transit agencies are in a quandary regarding use or non use of TCIP. During the technology assessment, it was determined that vendors were not interested in upgrading their systems to implement TCIP for transit projects of the nature and size of MART. MART decided to implement a project using the system engineering process and support development of a Regional ITS Architecture, but not to require implementation of the TCIP standard.

- Technical: MART's existing communications system did not provide adequate coverage for MART's service area. To compensate, MART used commercial cell phones. Together, these two voice systems still did not provide consistent

coverage within the MART service area. Cost of a new private radio network was prohibitive.

- Cellular Digital Packet Data (CDPD) communications technology was chosen to support the pilot program. This technology was available within the area, and has been successfully supporting other AVL programs.
- After deployment, MART determined several coverage issues still remained with the CDPD technology, and actual service coverage experienced did not match that presented by the commercial carrier. As with most rural areas, wireless communications service in the region is often spotty.
- Technical: MART's existing reservation and dispatch system is proprietary, developed over several years of modifications to meet changing requirements as the MART transit agency expanded their operations to meet expanding demand for the transit services. As such, integrating a new AVL system with an existing proprietary system posed several challenges, which, with consistent coordination, were overcome.
 - Design parameters for the enhancements and an interface control document for the existing system needed to be defined to support integration efforts. Through informal integration testing and using remote conferencing capabilities, each system vendor gradually gained sufficient knowledge in each other's system to define and conduct the integration.
 - During the informal testing phase, little configuration control was enforced by each vendor over their own systems. As a result, when the formal testing program was initiated, a baseline needed to be established for the testing.
 - Neither vendor had a formal configuration control process to support testing. MART enforced a software problem change report (SPCR) process for both contractors to follow which provided a traceable baseline during testing and provides a documented basis for future expansion of the system.

7 Lessons learned

The MART AVL/MDT project offers several lessons learned for agencies, particularly small rural agencies that plan to implement ITS technology in an incremental fashion. The lessons learned are presented in two general categories: Institutional and Technical.

Institutional:

1. Agencies using third party transportation service companies need to check their contract terms to ensure changes in operational procedures can be enforced with no break of contract or service. MART had difficulty coordinating with their providers to ensure staff was made available for training. Acquiring third party providers' commitment to the project, from the beginning, is a key element to operational success of the project.
 - This issue was resolved with extra training sessions and acquisition of training material to support refresher training. Additionally, MART has invested in development of an "in-house" trainer.
 - MART plans to complete installation of the ITS technology to the balance of their fleet. The third party providers will be included in planning and execution of the follow-on project.
2. The impact of employing a fleet with distinct and different system technologies to the agency's operating procedures was underestimated. Issues which needed to be addressed included:
 - Retaining proficiency in operation of the new equipment was underestimated. Keeping a group of drivers only for the equipped vehicles slightly mitigated this issue, but created others with respect to union rules and driver priority.
 - Scheduling was not as seamless as anticipated. In actuality, due to the pilot only covering approximately 10% of the fleet, the schedulers need to run two separate systems, therefore creating more work for them. The goal is to have the two systems integrated into one system prior to completing a full upgrade of the fleet with the new AVL/MDT technology.
 - Dispatcher's responsibility was also increased as a result of operating parallel scheduling systems. This is a temporary situation.
3. In-house customized systems and AVL/MDT system enhancements should follow the same or similar engineering process as those used to procure new systems. Without documented requirements specification, and disciplined configuration control, the agency risks cost and schedule growth as well as potential inability to integrate new and existing proprietary or customized systems.

Technical:

1. Hosting both the AVL and scheduling /dispatching systems, using Oracle and Microsoft SQL Server software respectively, on the same server platform created a compatibility issue which impacted the server performance. Once the two databases were physically separated onto two different servers, the performance issue was resolved. Evaluating system process load distribution needs to be part of the project-planning phase.
2. There were no outstanding technical issues. During the test and installation phase, both contractors discovered technical inefficiencies in their respective systems and made changes to satisfy all of MART's technical goals.