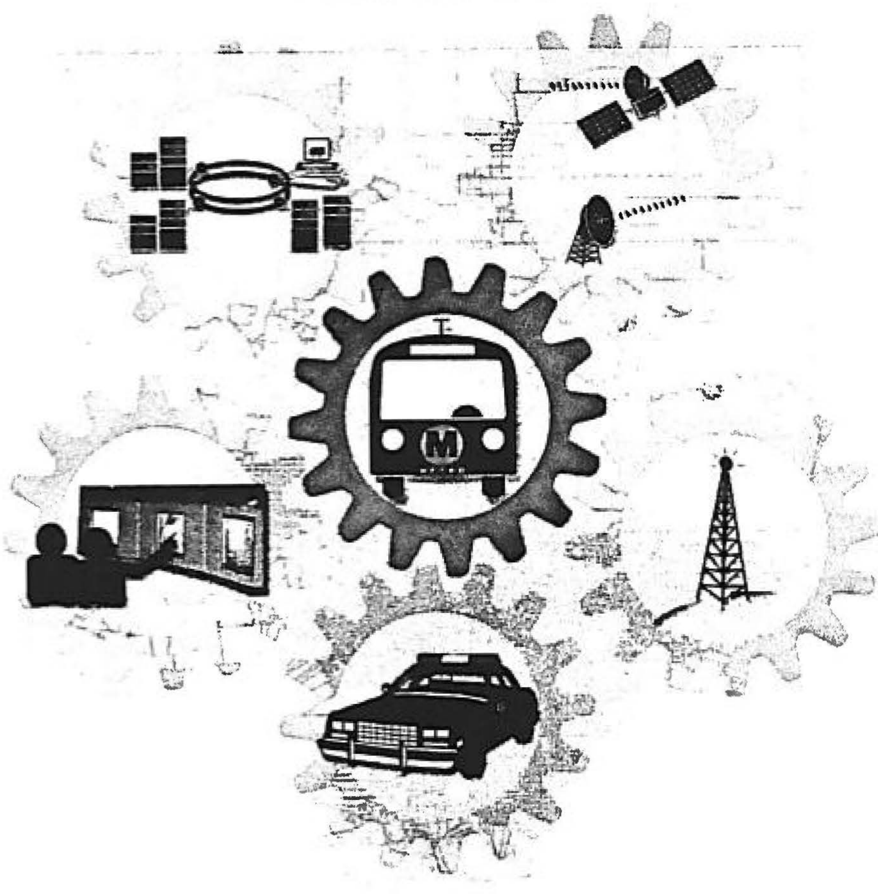
FINAL DRAFT

Submitted to the

Los Angeles County Metropolitan Transportation Authority

Advanced Transportation Management System (ATMS) Business Plan



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EXECUTIVE SUMMARY

Over the next three to five years, the Los Angeles County Metropolitan Transportation Authority (MTA) is planning to install an Advanced Transportation Management System (ATMS) for its transit bus fleet. Integrating several intelligent vehicle technologies, ATMS will provide the MTA with a sophisticated new tool to help operate and manage the bus fleet. ATMS offers the potential for the MTA to realize service improvements, increased efficiency, reduced operating costs and enhanced safety. By showing the foresight to acquire the technology needed to improve its business processes, the MTA will help pave the way for other transit agencies to make similar investments in the future.

To set forth a blueprint for implementing the system, the MTA has established an ATMS Steering Committee and commissioned this business plan. The business plan is intended to be a high-level, non-technical document that identifies the agency's business needs for ATMS and discusses functional requirements, needed supporting infrastructure, and costs and benefits associated with the project. The findings of the business plan form the basis for the conceptual design and technical specifications for ATMS.

ATMS Needs Assessment

To determine the MTA's business needs for ATMS, the TM TechSystems Team (Team) interviewed over two dozen key MTA executives, functional managers, and operations staff who would be affected by ATMS. Based on the results of these interviews and other research performed by the Team, general system requirements for ATMS were identified. Additionally, optional features for ATMS that may be implemented by the MTA in the future — but are outside of the present ATMS project scope — were also documented. To the maximum extent possible, ATMS will be designed to allow these options to be easily incorporated. Exhibit 1 summarizes the base system features and possible future options for ATMS.

Exhibit 1. Summary of ATMS Features and Options

Element	Base System Features	Future Options
General System Features	▪ Open architecture based on published standards ▪ Integrated but separable functionality ▪ Easily expandable ▪ Reliable ▪ Easy to use and maintain ▪ Option to buy or build	▪ Integration with IMAJINE, Rapid Bus, ATIS, Bus Signal Priority and other programs
Voice Communications	▪ Reliable communications ▪ Trunked radio system ▪ Public address system interface ▪ Flexible control head with external speaker ▪ Operator to field supervisor communications capability ▪ Request to talk to police capability	▪ Software upgrade to digital ▪ Expanded voice channels ▪ Expanded transmitter coverage ▪ Operator to operator communications

Element	Base System Features	Future Options
Data Communications	▪ Silent Alarm System (SAS) ▪ STAR signaling ▪ Supports all ATMS subsystems ▪ Fast, automatic wireless upload and download at bus divisions	▪ Use of commercial transmission service (e.g., CDPD, EDGE) for greater speed
Computer Aided Dispatch (CAD)	▪ Immediate priority response ▪ Usable Incident Response (IR) forms ▪ Streamlined data collection ▪ Faster construction and update of input database ▪ All-call function ▪ Priority based queue ▪ Provision of a supervisory control console (with access to all other consoles) ▪ Ergonomic design ▪ Workstations for mobile emergency control centers ▪ Mobile workstations for supervisors	▪ Large overhead monitor ▪ New control center facility with sufficient space for integrated operation of Inter-modal Transportation Management, Traffic Management, and Incident Management
Automatic Vehicle Location (AVL)	▪ Differential GPS with dead reckoning ▪ Accurate routes and stops data ▪ Well-managed GIS database ▪ Exception reporting	▪ Algorithm for "learning" routes and stops
Universal Fare System (UFS)	▪ Integration with AVL ▪ Single driver sign-on interface ▪ Dedicated control head ▪ Transmit data using yard LAN ▪ Remote polling capability	▪ Card reader at rear door
Automatic Voice Annunciation (AVA)	▪ Integration with AVL ▪ Interior and exterior speakers ▪ Variable message sign at front of bus ▪ Accurate stops database	▪ Variable message sign at rear door ▪ Advertising variable message sign(s) ▪ Multilingual capability
Automatic Passenger Counting (APC)	▪ Integration with AVL ▪ Sensors at all doors ▪ Transmit data using yard LAN ▪ Implementation on 100% of fleet	
Video Surveillance System (VSS)	▪ 72 hour storage capacity on removable media ▪ Color or high resolution black and white images ▪ Wireless link for download at yard ▪ Audio surveillance activated at operator's seat during a SAS ▪ Ability to transfer data to DVD or CD-ROM	▪ Real motion remote video transmission
Vehicle Health Monitoring (VHM)	▪ Alarm indications to driver ▪ Monitoring of engine, transmission, air conditioning and door ▪ Capability for remote transmission of warning alarms ▪ Fast, wireless data download to off-board storage system ▪ Interface with diagnostic software	• Monitor wheelchair lift functionality

Systems Support and Training

The MTA will need to implement several support systems for ATMS — during setup and on a continuing basis once the transition to ATMS has been completed. Moreover, during the transition period or cutover process, the MTA must support existing functions as well as new functions required for or supported by ATMS. The support system functions impacted by ATMS include:

- Prepare routes and schedules
- Schedule operators and supervisors
- Dispatch vehicles
- Maintain vehicles and equipment
- Handle data
- Maintain databases
- Create and distribute reports
- Operate central facilities
- Upgrade ATMS
- Run quality improvement

TM TechSystems estimates that 30 staff months are needed to setup ATMS, 13 full-time equivalent persons are needed to operate ATMS during the 18-month cutover period, and about 19 persons are needed to support ATMS on a permanent basis over and beyond current staff levels (see Exhibit 4-3 for more details). Staffing costs for these personnel are estimated at $4.4 million for an 18 month setup and transition, then $4.3 million annually thereafter.

Establishing quality training will be critical to the success of ATMS — only with a well-organized, well-supported, on-going training program will ATMS be able to achieve the benefits outlined herein. The MTA must establish well-structured and well-implemented training for bus operators, road supervisors, controllers, maintenance personnel, and computer systems and information management staff. The ATMS specifications will impose provisions to assure proper training delivery of ATMS technical topics to MTA staff. Training on internal policy, procedures, and improvement process must be organized by MTA staff, perhaps with assistance from consultants.

ATMS Costs

The scope of work for the ATMS project consists of complete voice and data communications, CAD, AVL, APC, AVA, video surveillance, interfaces to a smart farebox and vehicle health monitoring system, and fleet management capabilities for a MTA fleet of 2,400 vehicles. The scope include supporting data handling and reporting software that will run on the Enterprise Local Area Network (LAN), but excludes additional Enterprise LAN equipment. It is important to note that installation of APCs on 100 percent of the MTA bus fleet through ATMS will result in lower total costs than implementing a separate APC procurement. Thus, TM TechSystems has recommended and the Steering Committee has agreed that the standalone APC procurement be canceled and that all APCs be acquired as part of the ATMS work scope.

Implementation of ATMS will occur in two phases. The first phase will encompass the Core System — radio, CAD, AVL, APC, AVA and UFS interface. Video surveillance and a health monitoring system interface will be added in the second phase. The estimated integrated cost for each phase of ATMS, including components, material and labor, miscellaneous charges and contingency, are summarized in Exhibit 2. It should be noted that this cost estimate will be

1.0 INTRODUCTION

The Los Angeles County Metropolitan Transportation Authority (MTA) is embarking on a program to install an Advanced Transportation Management System (ATMS) for its transit bus fleet. Capable of integrating various Intelligent Transportation System (ITS) technologies — including transit radio, vehicle location, automatic passenger counting, fare collection, automated voice annunciation, video surveillance, and vehicle health monitoring — ATMS will provide the MTA with a sophisticated new tool to help manage and operate its bus fleet.

The MTA has retained a consulting team led by TM TechSystems to provide technical, planning and project management support to the agency over the three to five year period envisioned for ATMS implementation. To help guide the process, the TM TechSystems Team has prepared this business plan. The business plan is intended to be a high-level, relatively non-technical document that identifies the MTA's business needs for ATMS and describes functional and performance requirements, needed supporting infrastructure, and costs and benefits associated with the project. Additionally, the business plan sets forth the ATMS acquisition strategy and work plan.

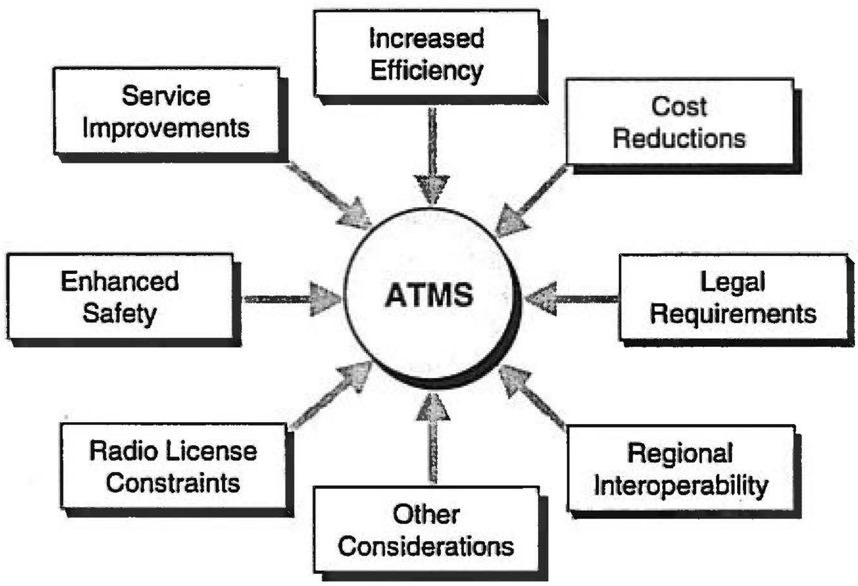
To support the development of this business plan, the TM TechSystems Team interviewed over two dozen key managers and employees of the MTA, regional stakeholders, and other transit agencies with experience in ATMS technology. Additionally, the Team sought direction and advice from the ATMS Steering Committee, a group of key MTA managers. The information collected during these interviews, the guidance of the ATMS Steering Committee, and the results of other research conducted by the Team, provide the basis for the contents of this business plan.

Although this document represents the Team's best understanding of the business case for ATMS at this time, it should be understood that the business plan is a living document. The findings and recommendations contained herein are likely to change as the baseline situation changes, new information emerges, and new technologies and policies are adopted.

2.0 BUSINESS PLAN DRIVERS

ATMS is driven by the MTA's needs to meet operational goals, comply with legal requirements, and promote better integration of regional transportation services. These and other factors have and will continue to help shape business requirements for ATMS (Exhibit 2-1).

Exhibit 2-1. ATMS Business Plan Drivers



2.1 MTA OPERATIONAL GOALS

The MTA is the primary provider of transit-related services in the Southern California region. As reflected in its mission statement, the MTA aspires "*to provide the leadership and resources for a safe, efficient transportation system that keeps LA County moving. A better tomorrow rides on us.*" Consistent with this theme, the MTA intends to use ATMS to help achieve several operational goals:

- Improve operator and passenger safety
- Improve service
- Promote efficiency and reduce operating costs.

Each of these three areas is discussed in further detail below.

2.1.1 Improve Operator and Passenger Safety

Similar to other agencies operating in urban environments, the MTA does occasionally experience incidents of assault, disturbances and theft onboard its buses. Property crimes, such as graffiti and other forms of vandalism, are recurring problems on certain bus lines. One of the MTA's goals for ATMS is to improve safety and reduce and deter incidences of crime throughout its bus system.

- More comprehensive, accurate and detailed data for routine analysis and special studies
- Better legal and risk management.

Operations
- Faster and more efficient communications between controllers and bus operators
- Faster and more efficient communications between on-street supervisors and bus operators, with more information available to supervisors
- Reduced bus breakdowns
- Quicker detection of and response to service disruptions
- Better monitoring of employee actions
- Better tracking of bus location en route and in the yard
- Reduced running and deadhead time
- Reduced manual labor.

Customer Service
- Better schedule adherence
- More reliable and better maintained buses
- Reliable and understandable stop announcements
- Better integration of regional transportation services
- Reduced service complaints
- Availability of real-time schedule information (future).

Maintenance
- Better preventive maintenance scheduling
- Ability to correct mechanical problems before failure occurs
- More sophisticated diagnostic tools to assist mechanics.

2.1.3 Promote Efficiency and Reduce Operating Costs

To justify the cost of ATMS, the MTA must ultimately derive some benefits in terms of greater efficiency and lower operating expenses. This is a strong driver for ATMS, as the MTA is relying on the system to provide data that will allow the agency to more efficiently and cost-effectively manage its bus fleet. Specific areas where efficiency gains and cost reductions can be realized include:

- Fewer buses operated due to more optimal schedule and route planning

- Decreased need for field supervision, manual route checking and passenger counting, and customer information telephone services

- Improved bus service planning and scheduling through automation of data collection

- Reduced road calls/bus downtime due to ability to better monitor vehicle health and to diagnose and address mechanical/electrical problems

- Reduced deadhead time and expenses due to better monitoring for schedule adherence and efficient use of time by operators.

2.2 LEGAL REQUIREMENTS

Like any business enterprise, the MTA is obligated to follow all federal, state, and local laws, regulations, orders and judgments. Failure to comply with legal requirements could result in fines, penalties or funding curtailments, as well as increase the agency's exposure to lawsuits. Consequently, ATMS must help enable the MTA to comply with its legal obligations.

2.2.1 Consent Decree

The Consent Decree dated October 29th, 1996 (*Labor/Community Strategy Center, et al., v. Los Angeles County Metropolitan Authority, et al.,*) requires the MTA to reduce bus overcrowding. The objective of the terms set forth in this document is to deliver quality service to MTA bus passengers. Quality service has been determined by the courts to equate to a bus load factor of 1.35 in the first phase and 1.25 in the second phase.

To monitor service quality, the Consent Decree requires that the MTA have the ability to determine passenger load factors for all existing and new buses. As an alternative to determining the load factor of each bus individually, the MTA can take a statistically valid sample that is an accurate representation of actual bus loads. In anticipation of the need to expand its fleet to meet the Consent Decree, the MTA has already made aggressive plans to procure more new buses. To help calculate load factors, the MTA has leased Automatic Passenger Counters (APCs) and is planning to implement APCs on its fleet.

APCs use commercially available technologies (e.g., infrared beam sensors, pressure mats, etc.) to detect boarding and alighting passengers. This technology, integrated with other ATMS components, provides a means to determine the bus load factors called out in the Consent Decree. Based on the APC data, the load factor requirements for each route with an overload can be reduced through addition of buses, adjustment of headways, or modifications to bus schedules.

2.2.2 Americans with Disabilities Act of 1990 (ADA)

A federal law, ADA protects people with physical impairments and disabilities by guaranteeing them access to public transportation. In particular, ADA requires transit operators to facilitate the boarding and alighting of passengers through the use of lifts, ramps, elevators, or low floor buses. To meet this requirement, the MTA has instituted a policy that wheelchair lifts on all buses be inspected prior to the first pull-out of the day. If the wheelchair lift is not operational, the bus is not allowed to go into revenue service. If the lift becomes inoperable during revenue service, an alternative means of transportation must be provided within 30 minutes — either through the next MTA bus or other means. Better monitoring of wheelchair lift functionality by ATMS could help the MTA assure that it complies with this ADA requirement.

ADA also requires all fixed route transit vehicles to provide stop information to passengers inside the bus and at major transfer points. Presently, bus operators are instructed to announce major intersections, key stops, and requested stops inside the bus using the vehicle's public address system. At major transfer points, the bus line number and destination must be announced to riders waiting at the bus stop. However, bus operators often do not do comply with this requirement. Adding the Automatic Voice Annunciation (AVA) component of ATMS will help ensure compliance with stop announcements as required by ADA.

2.3 REGIONAL GOALS

In the greater Los Angeles area, MTA buses operate alongside municipal transit agency buses, paratransit and dial-a-ride shuttles and vans, commuter rail, heavy and light rail trains, commercial vehicles, passenger cars and other means of transport. To help provide a more seamless and convenient transportation system for the general public, the MTA is striving to integrate regional transportation services and provide interoperability among different agencies. Consequently, ATMS must provide data/services in a format that is compatible for sharing with or use by other transportation agencies.

Several projects underway in the Los Angeles region have been identified as possibly impacting the design of ATMS. They include the Showcase Program, Bus Signal Priority Pilot Program, Rapid Bus, and Universal Fare Systems. The data available from ATMS may be used by these other programs, if they are interfaced to ATMS. Development of these interfaces, though, is not within the ATMS project scope.

2.3.1 Southern California Priority Corridor Showcase Program

The federally-mandated Southern California Priority Corridor includes Los Angeles County, Orange County, San Diego County and the Inland Empire Region. The Priority Corridor's Showcase Program consists of seventeen interdependent regional projects that — when taken together — form a corridor-wide network for sharing and disseminating transportation information between agencies and to the general public. Through the "Showcase Network," an agency in one part of the corridor can access information from any other agency anywhere else in the corridor. This promotes greater communication, improved coordination and more efficient use of the existing transportation infrastructure. The Showcase Program is managed by the Priority Corridor Steering Committee, which is comprised of representatives from each region of the corridor. Representatives from the Los Angeles region include the MTA, Southern California Association of Governments (SCAG), and Caltrans District 7.

The Showcase architecture specifies an object-oriented, Common Object Request Broker Architecture (CORBA) based communications protocol for sharing electronic data. Any agency that wishes to link to the Showcase Network must either have a "Showcase Compliant" system that uses Showcase-defined objects, or develop a "Seed" (i.e., legacy bridge) to translate data between Showcase and the agency's existing system.

IMAJINE

IMAJINE is one of the seventeen Showcase Projects and is managed by the MTA. IMAJINE enables an interagency exchange of transportation information between the MTA, Caltrans District 7, the City of South Gate (as a prototype for the future Gateway Cities Subregional Transportation Management Center), and Access Services Inc. (the county paratransit provider). However, the system is not restricted to these four partners, and additional agencies are free to join later as resources permit. Exhibit 2-2 below lists the types of information that the four current partner agencies make available through IMAJINE. In the future, IMAJINE may be integrated into a regional traffic signal prioritization system in which stoplights at intersections may be changed preferentially for transit buses.

Exhibit 2-2. Information Available through IMAJINE

Agency	Information/Data Type
MTA	• Static transit schedules/time tables • Incident advisories/event information
Caltrans D7	• Real-time highway congestion data • Incident advisories/event information
City of South Gate	• Real-time arterial congestion data • Incident advisories/event information
Access Services	• Incident advisories/event information

IMAJINE conforms to the Showcase Architecture, and its system design consists of remote workstations that act as an agency's gateway onto the Showcase Network. Specifically, an IMAJINE remote workstation does two things:

- Provides a Windows-like user interface for entering and viewing Showcase-related transportation information. Users of IMAJINE can access highway and arterial traffic congestion levels on a color-coded regional map, look up transit schedules, and enter/retrieve textual updates on incidents and planned events (such as maintenance and construction).

- Runs the "Seed" software that translates and exchanges data between the agency's existing legacy system (such as a transit route database, ATMS, etc.) and the object-oriented Showcase Network.

ATMS should have the ability to share information with IMAJINE workstations. Alternatively, ATMS could be designed to be fully Showcase Compliant, but this would have impacts on cost and schedule. In any case, data from ATMS would be made available to the IMAJINE project.

Los Angeles/Ventura Regional Advanced Traveler Information System (ATIS)

The LA/Ventura ATIS is another Showcase project in the LA area that is currently in its high level design and business planning phase. Like IMAJINE, the LA/Ventura ATIS will take

4.3.5 Automated Passenger Counting (APC)

Passenger count data is used by the MTA to improve route planning and scheduling and provide data for the National Transit Database, a requirement for the MTA to receive federal funding. Currently, the MTA is under a 1996 consent decree to reduce the overcrowding on its buses. Currently, passenger counts are performed by MTA schedule checkers, using onboard and wayside sampling techniques. An APC system can provide a significantly more reliable, accurate and comprehensive means of monitoring transit service quality.

The MTA had developed plans to procure APCs for 20 percent of the fleet to meet Consent Decree requirements. These APCs were slated to be standalone units and would have been implemented before the ATMS Core System is completed. This procurement has subsequently been merged into the ATMS procurement. The MTA is also currently leasing 60 standalone APCs, primarily to gather passenger counts for the National Transit Database, Section 15 Report. The lease project has been a success — the APC generated passenger data was used to create the 1999 Section 15 report. An additional benefit from this project has been the corrections made to the bus stop locations in the MTA's GIS database by using the GPS data collected for the stops by the leased APCs. The updates to GIS database should reduce the amount of GIS related efforts for the ATMS project.

The purchase of the standalone APC system is not recommended. The cost to implement a standalone system for 20 percent of the fleet is significantly higher than implementing APCs that are integrated with ATMS. A standalone APC system will cost $6,000 to $8,000 per bus while an integrated APC will cost $1,000 to $2,000 per bus. Thus, the $8 million budgeted for purchase and administration of the standalone system could be better used to equip the entire bus fleet with APCs integrated with ATMS. Furthermore, there would be significant support staff requirements, roughly 2.5 full-time equivalent persons to administer and implement a bus line sampling plan . The responsibilities of these staff include:

- Ensuring that the required number of APC-equipped buses is maintained at each division
- Ensuring sufficient numbers of each type of coach are maintained
- Ensuring the correct APC daily assignments are implemented
- Determining if assignments not fully worked
- Determining which bus lines to sample each day.

The sampling plan can be very costly and labor intensive and involves several departments. On the other hand, a sampling plan would not be necessary if the entire bus fleet is equipped with APCs. For a cost and resource standpoint, then, the Team recommends cancellation of the standalone APC procurement and acquisition of all APCs through ATMS. To satisfy the Consent Decree requirements, the MTA can show good faith by extending the current lease of the 60 APCs for a year and increasing the number of units leased by 60 until the ATMS Core System is completed.

4.3.6 Vehicle Health Monitoring (VHM)

VHM refers to automated monitoring and reporting of the functionality, performance and operation of key subsystems on a bus. By interfacing with the diagnostic sensors and electronic control modules provided by equipment vendors, ATMS provides a centralized processing unit capable of reading, storing and transmitting vehicle health data.

VHM coupled with ATMS technology will allow the MTA access to data on several critical bus subsystems and their operational status. The possible subsystems include:

- Vehicle speedometer and odometer readings
- Door operational status
- Engine speed, temperature, pressure, and fluid levels
- Transmission temperature and fluid levels
- Air conditioning operational status
- Electrical system functionality
- Wheelchair lift operational status (future)
- Operating status of all systems integrated with and monitored by ATMS.

Additional analysis is needed to determine the feasibility of implementing VHM on the existing equipment in the MTA's fleet.

The MTA intends to use data available from VHM to assist in diagnosing mechanical and electrical problems and in scheduling maintenance needs. Accordingly, the VHM system must be capable of interfacing with a diagnostic laptop for real-time data analysis at the bus yard. Additionally, ATMS must allow fast and easy downloading of VHM data for off-board analysis.

Another requirement for VHM is the transmission of warnings and advisories in real-time to the bus operator and the MTA control center. Having this information will provide an opportunity for the operator to take preemptive action before the bus breaks down. If that is not possible, then the control center would at least have some indication of the problem and can dispatch the right type of help immediately.

Successful use of VHM to achieve maintenance improvements requires a commitment to utilize the data. Only through analysis of data can trends be spotted so that preventative maintenance procedures can be implemented. In addition, maintenance of onboard sensors and their connections to ATMS must be emphasized in the MTA's day-to-day maintenance practices.

4.3.7 Video Surveillance System and Security Systems

Quick response to emergencies and prevention of onboard bus crimes are critical to the safety of the operator and passengers. Video surveillance can be an effective deterrent to crime, reducing illegal activities on transit vehicles. The MTA requires a video surveillance system that can store footage of the activities inside the bus as captured by video cameras. The recorded video will provide evidence that can be used in a court of law to prosecute offenders.

Additionally, the MTA has instituted an organizational policy that all buses be inspected for graffiti and "scratchitti" prior to roll-out. A video surveillance system can help support this "zero tolerance" policy by recording when vandalism is occurring and providing a method of identifying the perpetrator of these acts.

Both the Los Angeles Police Department (LAPD) and the Los Angeles Sheriffs Department (LASD) have special units that respond to MTA transportation-related incidents. The basic jurisdiction of the LAPD are buses located in the Los Angeles City and the Metro Red Line subway. The basic jurisdiction of the LASD are buses located in Los Angles County (outside Los Angeles City) and the Metro Blue Line and Green Line light rail systems. However, in specific situations, either or both of the transit police units may respond.

Currently, the MTA has two bus routes equipped with a Kalatel video surveillance system that utilizes three internal cameras and records video onboard the bus. The system also transmits pictures, via a cellular link, to the MTA when the silent alarm system is activated. All pictures are stored on an onboard hard drive that is capable of approximately 72 hours of video data storage. However, it has been the experience of the MTA that the video surveillance system is demanding on both video data storage and transmission. The amount of data provided by this system is a key issue affected by the following factors:

- Number of cameras
- Picture resolution
- Frames per second/refresh rate
- Recording in color (versus black and white).

Both LAPD and LASD have indicated that the present video surveillance system should be improved upon. The main problem is one of access; neither LAPD nor LASD have ready access to view the video images. For faster and more accurate response to emergency situations, both agencies have requested that a workstation be located at each of their dispatch centers that is linked to the video surveillance system, AVL data, radio, and other ATMS systems. Both agencies strongly prefer a real-time, color video system to allow a more precise description of perpetrators for police response and subsequent prosecution.

Other desires for the video surveillance and security systems as requested by one or both of the police agencies include:

- Installation of a "fish-eye" covert camera in the ceiling of the bus over the rear rows of seats

- A connection, preferably wireless, to the video surveillance system for use by police officers on-the-scene

- Capability for audio surveillance at the operator's seating area upon activation of a silent alarm (requested by LASD only)

- A non-reflecting strobe light installed at the roof of the bus that will activate with the silent alarm for easier spotting by police helicopters; also emergency strobe lights located near the existing headlight and tail-light of the bus

- Relocation or redesign of the silent alarm switch to prevent accidental tripping by bus operators

- A more portable and efficient means of transporting video images, for example, DVD or CD-ROMs

- Ability for bus operators to "mark" the video image, without activating the silent alarm, when they suspect criminal activities are occurring for easier retrieval of the footage later

- Capacity to store 7 to 30 days of video storage (requested by LASD only)

- Better training for controllers and operators.

Provision of video or other ATMS workstations outside of the MTA dispatch center is not currently within the ATMS scope of work and has not been included in the cost data presented in Section 5 of this business plan. Similarly, provision of external strobe lights is not currently within the ATMS scope or cost estimates.

Due to the data rate that video transmission requires, it is not feasible to provide for video transmission on an MTA-owned data radio system without adversely impacting the voice and data capabilities for other ATMS functions, particularly if ATMS were required to support video from more than one bus at a time. Current wireless services such as CDPD will not support good quality, full motion video. For these reasons, it has been determined that ATMS will not include transmission of video the control center. In the future, the MTA may re-evaluate the need for full-motion video at the control center, based on the following factors:

- Higher speed wireless data services that could support video-conference quality video will be available in Los Angeles within a few years.

- Short range transmission of good quality, real motion video to specially equipped vehicles in the area of the incident is feasible, without impacting the overall ATMS data radio scheme.

The MTA now operates a small fleet of buses equipped with onboard video surveillance. Approximately 300 new buses that are on order will include onboard video. It is assumed that these video systems will be integrated with ATMS for activation by the silent alarm, but that complete change-out of the equipment will not be required. As equipment is replaced during normal maintenance, commonality of video components will be achieved. The other MTA buses that have older generation video systems will be outfitted with all new VSS equipment under ATMS.

4.3.8 Computer Aided Dispatch

A core ATMS component is the controller workstation located at the MTA bus operations control center. Implementation of ATMS will require that present dispatch controller workstations be replaced. The ATMS workstations will include functions that will improve the safety and efficiency of the MTA bus fleet. Several workstations will be located at the control center remote facility, providing centralized monitoring and control of all of the ATMS components. The increased functionality of the workstations will facilitate:

- Increase in driver and passenger safety through enhanced bus location tracking and communications with the control center and transit police
- Improvement in scheduling and routing via the AVL system and through traffic signal preemption supported by the APC system through notification that a late bus is full enough to merit preemption
- User-friendly graphical user interface to improve overall system acceptance and emphasize intuitive thinking
- Accessible and usable Incident Report forms
- Optimized function allocation, allowing ATMS to route, store, and direct data and communications to reduce system bottlenecks and demands on controller
- Identify and prioritize radio communications
- Provide an "all call" function for controllers.

Controllers require an adjustable, well designed workstation to perform job functions efficiently and reliably. Key components that comprise the controller workstation include:

- Video display terminals
- Keyboard
- Chair design.

The design and setup of the workstation should fit the controller's own individual body proportions. The goal of an ergonomically designed and adjustable workstation is that the controller has a neutral body posture that is both comfortable and supportive. Key considerations when designing the workstation include:

- Reduce muscle strains and joint extension
- Decrease repetitive motions
- Reduce visual fatigue
- Place important and frequently used components closest to controller
- Arrange components functionally and/or sequentially.

The control center space is an issue in implementing ATMS. As new ATMS consoles are brought on-line and new ATMS servers and other hardware is required, there will be severe space constraints in the existing control center. It is recommended that the MTA renovate additional space adjacent to the existing control center or in another location to accommodate ATMS consoles and equipment. Building renovations are not currently within the ATMS scope and are not included in the costs presented in Section 5 of this business plan.

Additionally, as part of its emergency readiness plan, the MTA is building mobile control centers that have full bus dispatch capabilities. One such facility has been built inside a full-size transit bus, and two more are planned. With space for six controller workstations, the mobile control centers will allow the MTA to maintain dispatching service from a remote site in the event that its Gateway control center loses functionality. ATMS control capability will be incorporated into the MTA's mobile control centers, and ATMS consoles will be provided for the mobile control center as part of the core system.

4.4 SYSTEMS SUPPORT

Several support or interfacing systems will need to be put in place or modified to accommodate ATMS, and operated in parallel during the transition from TRS to ATMS.

4.4.1 Parallel Operation

Many of the supporting systems must serve both ATMS and TRS during the 18-month cutover period. Much of the scheduling and planning data, such as for operator assignments to vehicles and vehicle assignments to routes, will have to be divided between ATMS and TRS based on which vehicles have been upgraded to ATMS. This will either limit the flexibility of divisions to change assignments, or put greater workload on controllers to update actual assignments. Tools for these transitions will need to be developed to assure accurate transfer to ATMS, and tool users will need to be trained. Result data will have to be merged from the two systems, again with tools and training.

4.4.2 Required Support Systems

Routes and schedules will need to be prepared and updated for ATMS using the Enterprise LAN tools currently in use for TRS. There may have to be tools built that map these data to a form suitable for ATMS consumption. These include tools for preparation/update, transfer to ATMS and TRS, and transfer to buses/supervisors.

The scheduling and planning department uses Hastus software on an NT platform with an Oracle database. This may change, or the data it presents for ATMS may be changed as needed from the form for TRS. It is essential that ATMS have accurate schedule and route maps as well as stop locations for various functions to operate. ATMS will be specified to interface with the scheduling software to obtain updates. Currently, the MTA's Information Systems Department uses Thomas Brothers mapping and an ESRI software tool suite for route definition and maintenance. It is expected that this database will be used as the basis for the ATMS GIS database and that resources will be made available to update and upgrade this as necessary.

Operator and supervisor schedules will continue to be prepared on Enterprise LAN facilities. Those schedules will have to be divided between TRS and ATMS based upon the current vehicle configurations. Schedules will have to be coordinated with training functions to assure that operators are trained, and to provide sufficient staff for supervising, monitoring, and assisting operators and supervisors. Actual assignment information generated by TRS and ATMS will have to be merged for reporting.

Vehicle dispatching, including processes for readiness reporting, shop or yard location and for route assignment will be divided between TRS and ATMS during cutover. Vehicle identifications will have to be moved from TRS to ATMS in parallel with the designations of routes to which they will be assigned. Tools will be needed to maintain the accuracy of this function, and for the reporting of actual assignments.

Vehicle maintenance scheduling and results reporting will have to support parallel operation and transition during cutover from TRS to ATMS. Procedures and training will need to be in place for ATMS electronics maintenance before Phase I (Core System) installation. Procedures, staff, and training will be in place with current bus acquisitions to take advantage of the vehicle health monitoring available, and updated somewhat as major failure data are made available immediately.

Video surveillance record handling system will need to be set up before Phase II to provide convenient offload, analysis, storage, and chain of custody tracking. Parallel operation will not be needed.

Fare collection will be in transition during the same period, but it will not be synchronized with the transition from TRS to ATMS. If these transitions are not fully integrated, then there will have to be parallel tools for fares recording, cash handling and auditing, and fare/passenger count discrepancy resolution. These tools will have to deal with current fare collection, the new Universal Fare System on a TRS bus, the UFS on an ATMS bus, and possibly the current fare system on an ATMS bus.

Passenger count data will be new on ATMS. Additional passenger counting functions — including data capture, sampling plan administration, APC vehicle equipment division assignment, data inventory and reconciliation, and report distribution — will need to be set up.

AVA data preparation will need to be set up before Phase 2 to provide convenient updates to match schedules, as well as updates for advertising (if any) and other system information changes.

Management report data streams that will be generated by TRS and ATMS for changing subsets of the vehicles will need to be merged. The greatest challenge for this is to define the streams to have a consistent definition, or to identify the different meanings for the users.

Further, tools will need to be developed to merge the streams. New data from ATMS will require setup of new distribution.

Operation of TRS and ATMS central facilities will continue to operate in parallel during cutover. Routine operation of TRS, including data archiving and abnormal actions such as equipment switching and data recovery or repair, will continue. In addition, routine operation of ATMS with the same activities will start. Further, physical and logical console reconfiguration will be going on, and vehicles and staff tracking will be moved daily. Procedures, training, and staff for both facilities, need to be in place before cutover begins.

ATMS upgrades are likely to be needed immediately upon deployment in the first vehicles, and will continue for its life. Procedures and training will need to be in place for equipment performance and problem analysis, and for correction deployment. Similarly, procedures will have to be in place for software performance, problem, and feature analysis, and for change development and deployment.

Strategic choices on source for software upgrade design after the warranty period need to be made at least by early deployment so that staffing and training can be properly directed. Upgrades could be in-house, from the ATMS vendor, from an outside source, through a user consortium, or some combination of these. The choices will depend on the assessment of the ATMS vendor, and that vendor's apparent business strategy, client base, and approach to handling software versions and diversions. Since ATMS will probably not be totally off-the-shelf, the vendor may have little capability or interest in supporting custom parts. The following should be considered in the strategic choices:

- ATMS will use a combination of core communications and display software and custom software for user interaction, data retrieval, reporting, and perhaps additional communications functions. It will be a real-time package of substantial complexity, built upon standard tasking, user interface, data handling, and device handling tools.

- The vendor has the greatest expertise in ATMS software, but will not guarantee long-term support for its product, especially custom portions.

- The MTA will find it difficult to find and keep the kind of expertise it needs to do software upgrades. The initial investment in training will be substantial. There would have to be a fairly steady stream of changes to keep the experts familiar and interested.

- The in-house expertise will generally be more immediately available, and require the least management effort to direct.

- An outside source will seldom have the specific expertise needed in ATMS software.

- A consortium will be difficult to direct, with each member pulling for its favorite functionalities, priorities and architectures.

The basic strategy should probably be to develop and maintain an in-house capability, and to use vendor expertise when available and for Core System changes.

Vehicle maintenance staff and tools will have to be in place before ATMS deployment. As part of ATMS, vehicles will have new vehicle location units, automatic passenger units, automatic headsigns and voice annunciation systems, vehicle health monitoring systems, and video surveillance units. These will take new staff to maintain. Radios will be one-for-one replaced, so they should not require staffing changes. Test tools will be needed for new devices. Vehicle maintenance staff at each division will perform first echelon maintenance on electronic equipment, typically verifying failure and perhaps replacing fuses. The MTA currently has electronics maintenance staff located at its Regional Rebuild Center to complete diagnostics and repairs. They dispatch teams to the divisions with a truck-based shop, which will have to be equipped for the new devices.

Quality improvement processes need to be in place before ATMS deployment. The processes will provide an environment for cooperative, goals-based, customer-centered change. It will help open communications among the various parties to ATMS that are essential to success.

4.4.3 Staffing for ATMS Support Systems

The several ATMS support systems will need to be staffed by trained people at the start of ATMS deployment, during the period of overlapped operation with TRS, and after TRS has been retired. Exhibit 4-3 below shows the estimated MTA effort for:

- Setup before installation, excluding training (in staff months - SM)
- Effort to operate ATMS in addition to TRS during the 18-month cutover period (in equivalent positions - EP)
- Continuing effort to operate ATMS above current staff level after TRS is retired (in equivalent positions - EP).

Exhibit 4-3. Summary of Staffing for ATMS Support Systems

Support System Function	Setup (SM)	Parallel Op (EP)	Continuing Op (EP)
Prepare Routes and Schedules	8	0.3	
Schedule Operators and Supervisors	1	0.5	
Dispatch Vehicles	2	0.5	
Maintain Vehicles	2	0.2	
Handle Video Records	1	0.0	1.0
Handle Fare Data	2	0.3	0.3
Handle Passenger Count Data	2	0.2	0.2
Set Up Voice Annunciation	2	0.0	0.2
Create & Distribute Reports	1	0.1	
Operate Central Facilities	3	3.0	3.0
Upgrade ATMS	3	1.5	3.0
Maintain New Vehicle Equipment	1	5.0	10.0
Run Quality Improvement	2	1.5	1.2
Totals	**30**	**13.1**	**18.9**

4.5 TRAINING PROGRAMS

Timely, quality training is critical to the success of ATMS. Without it, ATMS users will resist it, make mistakes in its operation, or simply fail to use its capabilities. The MTA must establish a training program for personnel who are direct users or whose work will be affected by ATMS. Direct users are:

- Bus drivers
- Road supervisors
- Controllers
- Bus maintainers
- Computer systems and information management staff.

Those whose jobs are affected by ATMS are:

- Operations analysts
- Operations planners and schedulers
- Security staff
- Public affairs and public relations staff
- Managers.

This section describes the key considerations, features, and aids to success of the ATMS through training.

4.5.1 Timing During System Deployment

While ATMS will be implemented in a careful, controlled manner, the implementation schedule is aggressive. There will be considerable pressure to turn on ATMS before it is adequately wrung out, but even seemingly insignificant glitches would lead to distrust by operators so that its features would be misused or not used at all. Final training for direct users will be given just days before equipment is available, even though equipment installation will have to be staged over several weeks.

To mitigate the timing difficulties, the following actions must occur:

- Deployment will not start until ATMS is a stable, fully functional product. Field testing will involve only a minimum of direct users.

- Deployment will be paced by the rate of training as necessary. Training will not be provided too far in advance of the system so that trainees will have real-world experience shortly after their training program.

- Trainers and training facilities will be available in sufficient quantity, shifting trainers among divisions as necessary to meet peak load.

To achieve this, detailed training planning will start early in the development process.

4.5.2 Training Quality

To assure proper training delivery, the ATMS specifications will require that:

- Training materials are developed by experienced, effective training professionals

- Training materials accurately reflect equipment configuration and operation, and standard operating procedures

- Trainers are experienced, effective training professionals

- Presentation methods accommodate the range of trainee learning styles

- Measurement and evaluation are built into the training process, and into operating procedures

- Additional training is easily available to direct users as they feel the need

- Trainees have the prerequisite skills and computer literacy before training begins

- Trainees understand their part in the context of bus operation

- Trainees understand how ATMS will help them do their job more effectively.

Training requires strong MTA management support, chiefly in the time for the necessary personnel to be trained and the motivation for personnel to maximize their learning.

4.5.3 Description of Training Courses and Briefings

The following sections describe the ATMS training program courses and features.

Bus Operators

Bus operators will have a four-hour segment of primarily classroom instruction which includes bus startup and shutdown; use of the voice radio system and its call functions; operation of the data radio and messaging; operation of security features; use of routing features; operation of the AVL system; operation of APC equipment; operation of AVA equipment; VHM operation; and UFS and ATMS keypad training.

Bus operators will have a two-hour segment of working through the dispatch system. This will include classroom instruction on the functions of the dispatcher console, hands-on operation of the radio-related functions of the dispatch console, operation of a bus console while observing the answering dispatch console, and responding to a wide range of problem scenarios.

Materials and facilities needed include bus ATMS operations manual, procedures manual, workbook, and a fully functional bus console for each trainee, linked to a fully functional dispatch console and a fully-equipped road supervisor console.

Road Supervisors

Road Supervisors will receive the same four-hour and two-hour segments of training as bus operators. In addition, they will receive a two-hour segment of classroom and hands-on instruction on supervisor radio and other unique facilities.

Materials and facilities needed include a road supervisor's ATMS operations manual, procedures manual, workbook, and a fully-equipped supervisor's console for each trainee, linked to a fully functional dispatch console and a bus operator console.

Controllers

Controllers will receive the same classroom instruction on equipment operation as bus operators and road supervisors. In addition, they will receive 24 hours of classroom and hands-on instruction in use of normal and backup radio operation; radio call management; using the graphical interface to locate and track buses; using and changing bus patterns and schedules; accessing and changing operators, vehicle, line and run assignments; dispatcher work assignments and transfers; setting and initiating automated announcements; interpreting vehicle health data; working with phones and intercoms; creating and working with incident reports; use of notification tolerances; various soft skills pertinent to working with bus operators and road dispatchers including effective communications and understanding motivation and culture. The classroom work will include responding to a wide range of problem scenarios while working with the dispatch console and observing the interactions with road supervisor and bus operators and their consoles.

Materials and facilities needed include dispatcher's ATMS operations manual, procedures manual, workbook, and a fully functional dispatch console for each trainee, linked to a fully functional bus console and a fully-equipped road supervisor console.

Operator/Supervisor/Dispatcher Team Development Opportunities

Because a team concept is so important to operational communications, the MTA will provide opportunities for bus operators, supervisors and dispatchers to meet. These will include informal events such as open houses and formal mixed team processes for continuous quality improvement (CQI). The informal occasions will coincide with deploying ATMS at a division (therefore about monthly). The CQI sessions will start soon after deployment in divisions, and continue with two or three teams for the life of ATMS (see CQI training, below, and CQI Process in Support Systems).

Computer Familiarization Opportunities

To accelerate comfort and learning for bus drivers and road supervisors who are not computer-literate, the MTA will provide Internet/intranet access in ready areas. This will give access to computer-based ATMS training as well.

Follow-up Training, Mentoring, and Coaching

In addition to the formal training sessions, the MTA will arrange for follow-up skills development opportunities.

- Course presentation materials will be accessible on intranet facilities in ready and work areas.
- Controllers will make notes on bus operators and road supervisors who seem to be having trouble with some functions, or fail to use best techniques. These notes will be passed to division supervisors to work with bus operators on correcting problems. These notes will not be used in formal performance evaluation or discipline actions.
- During deployment at a division, at least one ATMS trainer will be available to answer questions from bus operators and road supervisors going on or coming off duty.
- Bus operators and road supervisors may sign up to retake training segments as needed.

Division Dispatchers

Division dispatchers will have a two-hour classroom segment on use and update driver assignment data; use and modify bus assignments; interpretation of bus performance and health data; and interpretation of bus status reports. The training will include hands-on operation of a division workstation.

Operations Analysts, Operations Planners and Schedulers

Analysts, planners, and schedulers will have a two-hour classroom segment on scheduling information needed (staff, vehicles) and development and entry of driver assignments. The segment will demonstrate use with typical data, including typical data inconsistencies. Analysts assigned to handling APC data will have a four-hour classroom segment on database handling, stop data maintenance, sampling plan, assignment verification, data cleaning, and report production.

Computer Systems and Information Management Staff

The staff responsible for daily operation of ATMS will have a 32-hour training segment on configuration and theory of operation of ATMS central, division, supervisor and bus equipment; use performance measurement and analysis tools; management of data archives; reconfiguration of equipment around failures; restoration of equipment and data after failures; management of system access and security features; development of changes to software; and use of system test tools. The training will be completed before the beginning of ATMS deployment, using final software and documentation.

Security Staff

Security staff, including both the LAPD and the Sheriff's Dept., will have a two-hour segment on handling video records; responding to live audio/video; and procedures for working with dispatchers, road supervisors, bus operators. This will include fire drill-like practice with a wide range of operating and emergency scenarios.

Public Affairs And Public Relations Staff

The staff that deal with the public for the MTA will have a one-hour training segment on the kinds of data collected by ATMS; the kinds of information that will be readily available to public; and the various legal requirements fulfilled through ATMS.

Managers

Managers at all levels and in all departments will receive a two-hour briefing on ATMS and on ATMS-related quality issues:

- <u>ATMS</u>: capabilities and limits; how to get what is needed from ATMS.

- <u>Quality</u>: overview; assessing organizational systems; information-based decision-making; customer service and the internal customer; coaching for creativity and innovation; managing transitions – the change process; continuous improvement tools for managers and their teams; management

- The mobile subsystem costs assume that the Mobile Data Unit (MDU) will be capable of SAE-J1708 interface to additional onboard subsystems.

- The central computer hardware and software is assumed to utilize open protocols and have capacity for ports to ITS elements. The cost of specific ITS applications is listed separately in the ITS element costs.

5.1.3 System Overview

The attached cost estimate is based on the recommended ATMS system that will provide complete communications, AVL, CAD, APC, AVA, video surveillance, interfaces to a smart farebox and vehicle health monitoring system, and fleet management capabilities for a MTA fleet of 2400 vehicles. The fareboxes and health monitoring system will be procured separately. ATMS will be implemented in two phases. In the first phase, the Core system — CAD, radio, AVL, APC, AVA and smart farebox interface — will be implemented. TRS will be maintained in service during the implementation of the Core ATMS system. The video system and the health monitoring system interface are the ITS elements to be implemented during Phase II. Since three hundred new buses are being provided to the MTA equipped with onboard video equipment, the quantity of video system to be implemented under ATMS is 2100.

The mobile subsystem will include a voice radio, MDU, control head, GPS unit, dead reckoning unit, data radio or CDPD modem, and a spread spectrum radio. The MDU will interface to the control head, radio, GPS, dead reckoning unit, and spread spectrum radio. It will also be interfaced to contact closures for mechanical indications and door status. SAS will also interface with the MDU. The MDU will be capable of future interface to additional onboard devices via an SAE-J1708 vehicle area network and via RS-232.

The control head will include an alphanumeric display and keys for operator interface. Log-in will be via a card reader or simplified key entry and will provide positive confirmation to the operator. There may be two sets of keypads onboard - one for UFS functions and the other for ATMS-related entries.

The GPS and dead reckoning units will work together to provide location. Differential correction data will be interfaced from the MDU. Door status will also be used to target the exact stop location and time.

The spread spectrum radio will be used for transmission of large quantities of data while in the bus yard — for example to modify route and schedule databases. This link is expected to operate at a minimum rate of 1.0 Mb/s.

The central computer hardware and software will utilize commercial off-the-shelf products and open architecture to the maximum extent practical. Distributed processing will be utilized to provide soft failure modes and to segregate real-time system functionality from lower priority functions. Front end processors for managing data communications with mobiles are anticipated and redundant local area network connections will be used to link all processors.

The central subsystem will interface to the existing corporate GIS and route and scheduling system. The central system will include a standard database and reporting package that will allow user-developed queries and custom reports. The central subsystem will be designed to be expandable to include interfaces to support future ITS systems.

Twenty dispatch consoles are anticipated. Each console will be equipped with two CRTs for the Graphical User Interface (GUI). It is assumed that the GUI will be based on the supplier's standard and will not be custom-developed for the MTA provided it meets MTA specifications and functional requirements. Each console will also be equipped with speakers and headsets for audio interface of radio and telephone communications.

All voice radio and telephone lines will interface to the system through a computer controlled switch. The switch will also provide for recording of all communications with dispatch consoles.

Two workstations will be provided at each division that are linked to the central subsystem via WAN connection. These workstations will be used for entry of daily work assignments and will provide a user-friendly means of editing assignment files. The work stations will also control the spread spectrum radio link to the buses used for large data transfers and non-time-critical data.

Associated with a procurement of this type and size are significant expenditures for project management and engineering. A significant amount of this expenditure will be in interfacing with the MTA regarding design and scheduling. The system documentation and training elements together provide a foundation for long term system support, but are dependent on active MTA participation. An adequate inventory of spares is necessary to maintain high availability, particularly for items that are not readily available. Warranty support for installed equipment for one year after system acceptance is included in the program cost.

5.1.4 Cost Estimates for Recommended System

The cost estimates for the recommended ATMS configuration are presented in the following tables for the Core System, Phase II system and totaled together as the Fully Integrated ATMS System. The cost for the Core System is estimated to be up to $78 million. If a CDPD system is chosen for the data communications, the Core System will cost $75 million; however, the costs do not include the monthly fee for CDPD service which is estimated to be $26 per month per bus or $748,000 per year for 2400 buses. The cost for Phase II is estimated to be up to $29 million, and the Fully Integrated ATMS cost is estimated to be $107 million.

Exhibit 5-1. Core System Costs

Subsystem	Cost
Trunked Simulcast Voice Radio Subsystem	$29,402,000
Data Radio Subsystem*	$6,528,000
AVL	$2,930,000
APC	$4,800,000
AVA	$14,400,000
UFS Interface	$1,160,000
Division Hardware	$660,000
Central Subsystem	$2,500,000
CAD Software	$2,500,000
Program Costs	$5,700,000
Supervisors and Emergency Dispatch	$575,000
Core System Mat'l & Labor	**$71,155,000**
Miscellaneous @ 10%	$7,115,500
ATMS CORE SYSTEM TOTAL	**$78,270,500**

* Cost assumes MTA's private radio network. For a CDPD system will be $3.6M Core System Total will be $75M.

Exhibit 5.2. Phase II Costs

ATMS PHASE II SYSTEM

Subsystem	Cost
Video System	$25,200,000
Health Monitoring Sys Interface	$1,300,000
Material and Labor Subtotal	$26,500,000
Miscellaneous @ 10%	$2,650,000
PHASE II SYSTEM TOTAL	**$29,150,000**

Exhibit 5-3. Total ATMS Costs

ATMS Core System*	**$71,155,000**
ATMS Phase II System	**$26,500,000**
Fully Integrated ATMS Mat'l & Labor	**$97,655,000**
Miscellaneous @ 10%	$9,765,500
FULLY INTEGRATED ATMS TOTAL*	**$107,420,500**

* Cost assumes an MTA data radio network. For a CDPD system, the total ATMS Fully Integrated System will cost $104M.

Exhibit 5-4. Subsystem Costs for Core System

Trunked Simulcast Voice Radio Subsystem

	Item	Unit Cost	Quantity	Extended Cost
Mobiles	Radio	2,700	2,400	6,480,000
	MDU w/Data Head	5,000	2,400	12,000,000
	Spread Spect Radio	600	2,400	1,440,000
	Inst & Test	700	2,400	1,680,000
	Misc HW	700	2,400	1,680,000
	Subtotal (Mobile)	**$9,700**	**2400**	**$23,280,000**
Fixed Site	Voice Repeater	18,000	9	162,000
	Trunk Controller	45,000	1	45,000
	Simulcast Controller	75,000	1	75,000
	TX Antenna Line	25,000	2	50,000
	RX Antenna Line	25,000	1	25,000
	Meter Panel & Alarms	10,000	1	10,000
	Racks & Cabinets	10,000	1	10,000
	Factory Inst & Test	20,000	1	20,000
	Field Inst & Test	20,000	1	20,000
	Misc Site Improvements	100,000	1	100,000
	Subtotal (6 Sites)	**$517,000**	**6**	**$3,102,000**
Comm Switch	Main Trunking Controller	750,000	1	750,000
	CAD Interface	250,000	1	250,000
	Central Electronics	1,000,000	1	1,000,000
	Consoles	20,000	20	400,000
	Voters	20,000	9	180,000
	Recorder	40,000	1	40,000
	Field Inst & Test	400,000	1	400,000
	Subtotal (Comm Switch)			**$3,020,000**
Trunked Simulcast Voice Radio Subsystem Total				**$29,402,000**

Private Network Data Radio Subsystem*

Subsystem	Item	Unit Cost	Quantity	Extended Cost
	Data Channel Proc & Modem	70,000	8	560,000
	Data Repeater	26,000	8	208,000
	Data Radio	2,200	2,400	5,280,000
	Inst & Test	200	2,400	480,000
	TOTAL	**$6,528,000**	**1**	**$6,528,000**

CDPD Data Radio Subsystem*

	Item	Unit Cost	Quantity	Extended Cost
	CDPD Radio Modem	1,000	2,400	2,400,000
	Inst & Test	200	2,400	480,000
	Data Channel Proc & Modem	70,000	10	700,000
CDPD Data Radio Subsystem Total				**$3,580,000**

*** CDPD would be used in place of Private Data Radio Network**

AVL Subsystem

	Item	Unit Cost	Quantity	Extended Cost
	GPS	600	2,400	1,440,000
	Dead Reckon	600	2,400	1,440,000
	Reference Station	50,000	1	50,000
AVL Subsystem Total				**$2,930,000**

APC Subsystem

	Item	Unit Cost	Quantity	Extended Cost
	Automatic Passenger Counters	2,000	2,400	4,800,000
APC Subsystem Total		**$2,000**	**2400**	**$4,800,000**

AVA Subsystem

	Item	Unit Cost	Quantity	Extended Cost
	Automatic Voice Annunciators	6,000	2,400	14,400,000
AVA Subsystem Total		**$6,000**	**2400**	**$14,400,000**

UFS Interface

	Item	Unit Cost	Quantity	Extended Cost
	Interface Hardware	400	2,400	960,000
	Software Support	200,000	1	200,000
UFS Interface Total				**$1,160,000**

Division Subsystems

	Item	Unit Cost	Quantity	Extended Cost
	Workstation (Two positions at $15,000 each)	15,000	2	30,000
	Wireless LAN Access Point	5,000	1	5,000
	Inst & Test	20,000	1	20,000
Division Subsystems (12) Total		**$55,000**	**12**	**$660,000**

Central Subsystem

	Item	Unit Cost	Quantity	Extended Cost
	Hardware & Software	2,500,000	1	2,500,000
Central Subsystem Total		**$2,500,000**	**1**	**$2,500,000**

CAD Subsystem

	Item	Unit Cost	Quantity	Extended Cost
	Custom Software Development	2500000	1	2500000
CAD Subsystem Total		**$2,500,000**	**1**	**$2,500,000**

ATMS Program

	Item	Unit Cost	Quantity	Extended Cost
	System Integrator Management	1,000,000	1	1,000,000
	System Integrator Engineering	1,500,000	1	1,500,000
	Documentation	500,000	1	500,000
	Training	300,000	1	300,000
	Spares	1,500,000	1	1,500,000
	Warranty	900,000	1	900,000
ATMS Program Costs Total				**$5,700,000**

Supervisors and Emergency Dispatch

	Item	Unit Cost	Quantity	Extended Cost
	Voice Radio	2,700	50	135,000
	Mobile Data Terminal	6,000	50	300,000
	CDPD Radio Modem	1,000	50	50,000
	Spread Spectrum Radio	600	50	30,000
	Inst & Test	1,200	50	60,000
Supervisors and Emergency Dispatch Total				**$575,000**

Exhibit 5.5. Subsystem Costs for Phase II

	Item	Unit Cost	Quantity	Extended Cost
Video	Video System	12,000	2,100	25,200,000
Health	Hardware Interface for HMS	500	2,400	1,200,000
Monitoring	Software Interface for HMS	100,000	1	100,000
Phase II Totals				**$26,500,000**

5.2 ESTIMATED COST FOR MTA INFRASTRUCTURE

Set-up and ongoing operation of the ATMS support systems will require labor hours from a variety of new and existing MTA staff positions. Specifically, these MTA staff will be required to perform the systems support functions and level of effort as reported in Exhibit 4-3.

Estimates of the cost in labor and materials required to complete each of these support functions by project phase are presented below in Exhibit 5-7. These cost estimates were derived using the detailed wage, benefits, overhead and other cost data reported in the MTA's annual operating budget and utilized the following assumptions:

- All ATMS support system functions are assumed to be completed by MTA staff. Specifically, for each support function identified in Exhibit 4-3, technical and supervisory positions were selected from the MTA's existing listing of job titles as appropriate to best fulfill the skills required to perform that function. Hourly wage rates were then constructed as a blend of these technical and supervisory wage rates required to complete each support function (based on current technical staff to supervisory staff ratios at the MTA).

- Cost and wage data are adjusted for inflation. To capture the impact of cost increases due to inflation over the set-up, parallel operations (with TRS) and ongoing operations periods, all wage and cost data have been inflated based on recent rates of cost and earnings increases in the Los Angeles Metropolitan area as reported by the Bureau of Labor Statistics. Specifically, the pre-installation set-up phase is assumed to take place late in 2000, the period of parallel operations of ATMS in addition to TRS over the eighteen month period covering all of 2001 through the first half of 2002 and the estimates of the cost of annual continuing operations of ATMS are based on 2002 dollars.

- Loadings for materials, benefits, overhead and other expenses. Exhibit 5-7 reports both the direct labor wage costs as well as fully loaded labor costs with provisions for fringe benefits, overhead, materials, professional services and liability costs as appropriate to each position (and as reported in the MTA budget).

- Adjustments for holidays, vacation and illness. The labor requirements outlined in Exhibit 4-3 represent the actual labor input required to perform each function. However, staff also obtain payment for staff vacation and holiday time, and periods of illness. The cost estimates have been inflated to account for these additional labor hours.

Exhibit 5-7. MTA Costs for ATMS Support Systems

Support System Function	Labor Costs Only (Wages)			Full Staffing Costs[1]		
	Setup[2]	Parallel Operations[3]	Continuing Operations[4]	Setup[2]	Parallel Operations[3]	Continuing Operations[4]
Prepare Routes and Schedules	$57,500	$41,700		$145,000	$105,200	
Schedule Operators / Supervisors	$5,800	$55,800		$12,600	$121,600	
Dispatch Vehicles	$9,400	$45,400		$20,400	$98,800	
Maintain Vehicles	$10,800	$20,900		$36,700	$71,000	
Handle Video Records	$4,200		$56,900	$9,100		$123,900
Handle Fare Data	$8,700	$25,300	$17,900	$19,00	$55,100	$38,900
Handle Passenger Count Data	$8,700	$16,900	$11,900	$19,000	$36,700	$25,900
Set Up Voice Annunciation	$11,800		$16,100	$40,100		$54,800
Create & Distribute Reports	$4,300	$8,400		$9,600	$18,500	
Operate Central Facilities	$17,200	$331,900	$234,300	$37,400	$722,700	$510,200
Upgrade ATMS	$17,700	$171,200	$241,700	$60,200	$582,200	$822,000
Maintain New Vehicle Equipment	$5,300	$510,200	$720,400	$17,900	$1,735,500	$2,450,300
Run Quality Improvement	$13,300	$192,900	$109,000	$29,00	$420,100	$237,300
Totals	**$174,700**	**$1,420,600**	**$1,408,200**	**$408,000**	**$3,967,400**	**$4,263,300**

1 Full staffing costs including labor, materials, fringe benefits, fuel, overhead, liability and professional services as appropriate to each function.
2 Assumed to start in 2001
3 Assumed to cover eighteen month period from late 2002 through the end of 2003
4 2004 Year of Expenditure Dollars

5.3 EXPECTED BENEFITS

Implementation of ATMS should result in significant safety, operations and efficiency improvements for the MTA's bus system. However, the extent to which these benefits are realized will depend on how effectively the information provided by ATMS will be used. By implementing effective training and continuous quality improvement programs, the MTA should be able to realize significant cost reductions.

5.3.1 Experience of Other Transit Agencies

The U.S. Department of Transportation has accumulated and published the benefits from ITS projects across the country. In its report, Intelligent Transportation Infrastructure Benefits: Expected and Experienced (January, 1996), U.S. DOT lists the following range of benefits reported by various ATMS-type projects for transit systems:

- Platform (e.g., total bus in-service) time decreased by 15% to 18%
- On-time performance increased by 12% to 23%
- Faster response to emergency incidents to as little as one minute

- 45% annual return on investment.

In Intelligent Transportation Systems Benefits: 1999 Update (May 28, 1999), U.S. DOT lists the following case studies of benefits experienced by transit agencies implementing some of subsystems of ATMS:

- The Transit Authority in Winston-Salem, North Carolina, evaluated the effects of a computer-aided dispatch and scheduling system on the operation of a 17 bus fleet. During a 6-month period, the client list grew from 1,000 to 2,000, and vehicle miles per passenger-trip grew 5%. At the same time, operating expenses dropped 2% per passenger trip and 9% per vehicle mile. These productivity improvements occurred at the same time that other service improvements were incorporated. As a result, it is difficult to isolate the effects of the CAD system. These improvements included the institution of same day reservations, which grew to account for 10% of trips. Also noted was a decrease in passenger wait time of over 50%.

- After an extended analysis of travel times, Kansas City Area Transportation Authority (KCATA), was able to reduce up to 10% of the equipment required for some bus routes using an AVL/CAD system. The system allows fewer buses to serve those routes with no reduction in customer service. The result is a savings in both operating expense and capital expense by actually removing these buses from service and not replacing them. The productivity gain of eliminating 7 buses out of a 200 bus system allowed KCATA to recover its investment in AVL in two years. Other transit systems have reported reductions in fleet size of 4% to 9% due to efficiencies of bus utilization.

- KCATA improved on-time performance by 12% in the first year of operation using AVL, compared to a 7% improvement as the result of a coordinated effort to improve on-time performance between 1986 and 1989. Preliminary results from Milwaukee County Transit System indicate a 28% decrease in the number of buses more than one minute behind schedule. The Mass Transit Administration in Baltimore, Maryland, reported a 23% improvement in on-time performance by AVL-equipped buses.

Other anecdotal reports of cost savings and revenue enhancements reported by transit agencies implementing ATMS-type systems are summarized in Exhibit 5-8.

Exhibit 5-8. Anecdotal Reports of ATMS Economic Benefits

Transit Agency	Cost /Revenue Benefit Reported
London, Ontario	AVL system will provide schedule adherence on a continuous basis, saving $40,000 to $50,000 previously spent on each schedule adherence survey
Rochester-Gennesee Regional Transportation Authority	Automated transit information system will allow elimination of 4 part-time information agents
Milwaukee County Transit System	CAD AVL system will allow a reduction in the number of street supervisors

Transit Agency	Cost /Revenue Benefit Reported
New York MTA	Initial projections were that MetroCard system will save $70 million per year in fare evasion; result in increased revenues of $34 million from merchant fees and revenue float, $140 million in unused value on the cards, and $49 million from increased ridership. Due to changes in fare policy enabled by Metrocard, NYMTA has experienced bus ridership increases in the range of 30%.
MARTA (Atlanta, GA)	Smart Card will significantly reduce cash handling costs, now budgeted at $3 million
New Jersey Transit	Savings of $2.7 million estimated in reduced handling of fare media; increased revenues of 12% after automated fare collection
SEPTA (Philadelphia, PA)	$3 million reduction in insurance claims in 1997 after installing video surveillance systems on 26 buses

5.3.2 Estimated Cost-Effectiveness for MTA

As discussed in the previous section, operating cost savings of as much as 8 or 9 percent per vehicle mile have been reported by transit agencies that have implemented some, but not all, of the subsystems that will be included in ATMS. Discernment of the exact benefits of ATMS is difficult as its impacts will be commingled with other policies, programs and economic factors. For these reasons, it is difficult to quantify the true cost-effectiveness of ATMS with any certainty.

To provide some context to the cost of ATMS, however, it is possible to quickly calculate the savings in operating expenses that must be achieved by the MTA to offset the cost of acquisition and operation. For the six-year period from fiscal year 1999 through 2004, the MTA has committed $3.82 billion of its total budget to bus operations. An additional $289.3 million has been allocated to expand current bus operations in accordance with Consent Decree requirements, resulting in a total bus operations budget of $4.11 billion over 6 years. Note that this cost does not include any capital costs (e.g., new bus procurements) or commitments to regional transportation operations.

Over the same time frame, ATMS is expected to require an MTA investment of approximately $114 million (Exhibit 5-9) to purchase and install ATMS, allocate staff for setup and parallel operations during the cutover period, and train its staff on how to use and maintain the system from fiscal year 1999 to 2004. Thus, the start-up cost of ATMS is approximately 2.8 percent of the MTA's total bus operations budget. In other words, if the MTA can achieve a 2.8 percent cost savings from implementing ATMS over the six-year period, ATMS will have paid for itself. In view of the benefits reported by other transit properties, achieving this level of cost savings certainly seems possible.

Exhibit 5-9. Summary of Capital and Set-up Costs for ATMS

Cost Element	Estimate
ATMS Core System Total Cost	$78,270,500
ATMS Phase II System Total Cost	$29,150,000
MTA Labor for Setup and Parallel Operations	$4,375,400
Initial Training	$1,863,000
Total Initial Investment	**$113,658,900**

If the total initial investment value of $114 million shown in Exhibit 5-9 is amortized over 14 years at a discount rate of 7 percent, the annual equivalent cost is $13.0 million. The 14 year life assumes that all costs are amortized over the life span of a typical bus; this is a conservative assumption since many of the ATMS subsystems will have considerably longer useful lives (e.g., trunked simulcast radio system, division hardware). However, a conservative assumption is appropriate for the purposes of this simplified analysis.

Adding the $13.0 million amortized annual investment together with the $4.26 million in annual staff costs expected to support ATMS yields an annual equivalent cost of $17.3 million per year attributable to ATMS. This value is 2.7 percent of the MTA's operating expenses for buses as reported in the 1998 National Transit Database. Therefore, a 2.7 percent reduction is required for the MTA to "breakeven" on the ATMS project. Any reductions in operating expenses above 2.7 percent would result in a net positive return for ATMS.

It should be noted that this is a pessimistic or conservative analysis of the required reduction in operating costs. The MTA currently has a real cost for supporting TRS, the APC lease and the existing onboard video. The MTA will have a cost for supporting the 300 new onboard video systems being procured. These costs are avoided by rolling support into ATMS, so the incremental cost for ATMS is actually much less than the annual equivalent cost of $17.3 million. Further, it should be noted that APC and AVA was intended as a standalone procurement that has now been rolled into ATMS. In short, if each of the elements of ATMS were to be procured separately, the annual equivalent cost would have been much higher than for the integrated implementation, resulting in cost avoidance savings.

To provide an example of the operating cost savings possible with ATMS, note that one of the possible benefits is reduced deadhead time. By better monitoring vehicle location through ATMS, it may be possible to adjust the bus pull-out time so that some buses can leave the yard a few minutes later and still make it to the first passenger stop on time, resulting in operating cost savings. At present, MTA's Scheduling Department estimates the cost of operating a bus at $20.25 per hour or $0.3375 per minute. There are a total of 721,656 pull-outs in the MTA system per year. Therefore, if every pull-out could be reduced by just one minute, the savings per year would be $243,559. If four minutes could be shaved from every pull-out, the cost savings would be nearly $1 million per year.

6.0 ATMS ACQUISITION STRATEGY

ATMS is being developed for implementation by a System Integrator as the prime contractor. The system integrator will have overall responsibility for the implementation of ATMS, including acquisition of all hardware and software and all labor for system installation. The MTA's Technical Support Manager, TM TechSystems, will monitor the contractor's activities throughout the process.

ATMS is being implemented in two main phases. Because there are eight subsystems being integrated under ATMS, the two phase approach allows the "core" functionality to be fully implemented and proven prior to adding on the other components, thereby reducing risk.

6.1 RECOMMENDED ACQUISITION APPROACH

There are two basic approaches available for acquiring the ATMS System Integrator:

- Negotiated acquisition
- Low bid.

Negotiated acquisition involves bidders providing a proposal that has a level of technical detail necessary to determine their approach to compliance with the Request for Proposals (RFP). The RFP defines the information that must be supplied with the bidders' proposals. Proposals are evaluated, discussed with the bidders at presentations, and any needed clarifications are requested. This process results in both sides gaining a greater understanding of what the final system will look like, what the greatest challenges are, and what trade-offs might be prudent. When negotiations are concluded, the bidder is requested to submit a "best and final offer" (BAFO) that includes technical refinements and final costs. The bidder's proposal is generally considered an attachment to the contract, with *lower order of precedence* than the RFP. This locks in any "enhancements" that the contractor promises during the bid process.

With a low-bid procurement, technical compliance is generally based on the bidder's statement that it will comply, with any exceptions listed. There is no way of knowing what the details of the compliance approach are. Qualification is based on the reputation of the bidder and its financial capacity.

The Negotiated Procurement approach has the following advantages, compared to the traditional low-bid procurement:

- <u>Proposal Defines Approach, Subsystem Vendors</u>. The proposal provides the MTA with an opportunity to clearly understand the bidder's approach to the project, including the manufacturers or vendors of major subsystem components. This creates a clearer common understanding of the System.

- <u>Reduces risk</u>. The proposals are evaluated for technical compliance based on knowing the bidder's approach and proposed design. This reduces the risk that an unqualified bidder will be selected, or that the bidder will have misunderstood the system requirements and is bidding an unacceptable system.

- Enhancements are identified. As the bidder knows that its proposal is being evaluated, the bidder has an incentive to propose a system that not only meets, but exceeds the stated minimum requirements of the RFP. The bidder may offer these at no additional cost or may propose them as options. The MTA will then have the opportunity to include these enhancements in the base contract, rather than negotiate them later as a change order.

- Trade-offs are identified. There may be some functions required by the specification that dramatically affect the bid price, based on the bidder's particular approach to the system. If the MTA does not highly value these functions, it may be advantageous to modify some of the functional requirements of the system to achieve cost savings in one area that can be applied in another. The proposal and negotiations process identifies these possibilities and allows them to be included in the contract.

- Firm qualifications does not guarantee sound technical approach. System Integrators that have proven track records in advanced transportation management systems have undergone numerous changes in ownership and several consolidations, mostly due to the competitive nature of the market and the relatively low profit margins. These firms are under pressure to perform financially in a way that may result in an unsound technical approach. The proposal process will allow evaluation of the basic proposed design.

- Lowest bid is not necessarily the lowest system life-cycle cost (best value). The low bid process places all value on the initial cost of the system. With an extended expected life-cycle, the recurring costs of maintaining and using the system including lost opportunity costs are more important. With a negotiated procurement, the total life-cycle value of the system can be evaluated in selecting the winning bidder.

The only perceived disadvantage of a negotiated approach is the time needed for negotiation. However, this "lost time" is recovered as the selected vendor in a negotiated procurement will have a greater understanding of the project requirements that it would otherwise have to gain after contract award. In effect, the technical proposal (BAFO) is the Conceptual Design Review (CDR) document.

The MTA procurement process is subject to Public Utilities Code Section 13028 for procurement by competitive negotiation. This requires that the MTA Board approve the procurement as a negotiated procurement prior to it being advertised. It is imperative that this Board approval process be completed in time so that the ATMS schedule is not impacted.

Based on the above, it is recommended that the ATMS System Integrator be procured using a negotiated procurement. In order that ATMS schedule not be delayed, the Board Action for authorization to use negotiated procurement should be pursued at the February or March, 2000 Board meetings.

The second phase of ATMS will also be implemented by the System Integrator. A basic description of the second phase system elements (as defined in the next section) will be provided in the RFP for the System Integrator. The System Integrator will then have the opportunity to participate in the development of the details of the functional specifications. The MTA and ATMS Technical Support Manager will work with the System Integrator to refine the functionality for the phase two systems. Some of the key advantages of this approach are:

- The System Integrator contractor will be the contract-holder, not MTA, in order to provide a single point of accountability, in line with the System Integrator approach.
- This second phase of procurement in effect creates a partial design-build approach, with all of the advantages and none of the disadvantages associated with design-build.
- The second phase minimum requirements should be only conceptually defined in the RFP. This will result in an efficient use of time in RFP development and in the proposers' bid preparation.

Allowances or non-evaluated bid prices for the second phase procurements should be included in the bid for RFP. This will provide the contractor with incentive to work with the MTA to have the maximum functionality defined for these items and to allow the MTA's representatives to participate in the bidding and selection process for this equipment. If the bidders are required to competitively bid the second phase with the System Integrator RFP, the System Integrator's motivation in these follow-on procurements will be strictly low-cost.

It is recommended that allowances be used, rather than non-evaluated bid prices, as the bidders would not be able to allocate larger profit margins to the allowance items, as might occur if the second phase items were bid, but not evaluated. Also, the bidders will not have to spend time preparing estimates for the phase two equipment.

It is recommended that authorization for the phase two procurement by this approach be included in the Board action, as described above.

6.2 RECOMMENDED ACQUISITION PACKAGING

The first phase or "Core System" has been defined to include the following elements:

- Radio – The radio subsystem includes voice and data radio communications and complete Computer Aided Dispatch (CAD). The on-vehicle radio package, repeater site equipment and control center equipment is included. Silent Alarm Switch (SAS) is included in the radio subsystem.

- Automatic Vehicle Location (AVL) – The AVL subsystem includes the onboard GPS receiver and inertial navigation unit. Also included is the onboard route and schedule database for tracking adherence.

- Automatic Passenger Counters (APC) – The automatic passenger counters include the onboard sensors at the doors, database storage and correlation to stops, and means to off-load the data, store and analyze it.

- Universal Fare System (UFS) – The UFS equipment is being procured under a separate contract. Under ATMS, data will be shared between ATMS and UFS, including log-on information, alarms and locations. ATMS will provide for an operator control head that is stacked with the UFS control head. Also, ATMS will provide for automatic download of UFS data at divisions for centralized storage and analysis of this data.

- Automatic Voice Annunciation (AVA) – The AVA equipment will automatically provide audio and visual stop announcements. This will meet the intent of the ADA.

The radio and AVL, as defined above, provide a functional replacement of the existing Transit Radio System (TRS) with some enhancements. These two elements are top priority as they are necessary for safe, efficient operation. APC has been included in the core system to satisfy consent decree requirements, as described elsewhere in this document. As UFS is being procured slightly in advance of ATMS, it will be necessary for the first phase of ATMS to support UFS functionality. AVA is included in the core system due to the need for ADA compliance. At the end of phase one, the Core System will support the MTA's most important business needs.

The Second Phase of ATMS has been defined to include the following elements:

- Video Surveillance System (VSS) – The VSS will record video from cameras onboard the bus. Video images will also be transmitted to the control center.

- Vehicle Health Monitoring (VHM) – The VHM will interface to existing bus engine and transmission controllers and other sensors. Data from these devices will be collected, downloaded and stored.

6.3 WORK PLAN

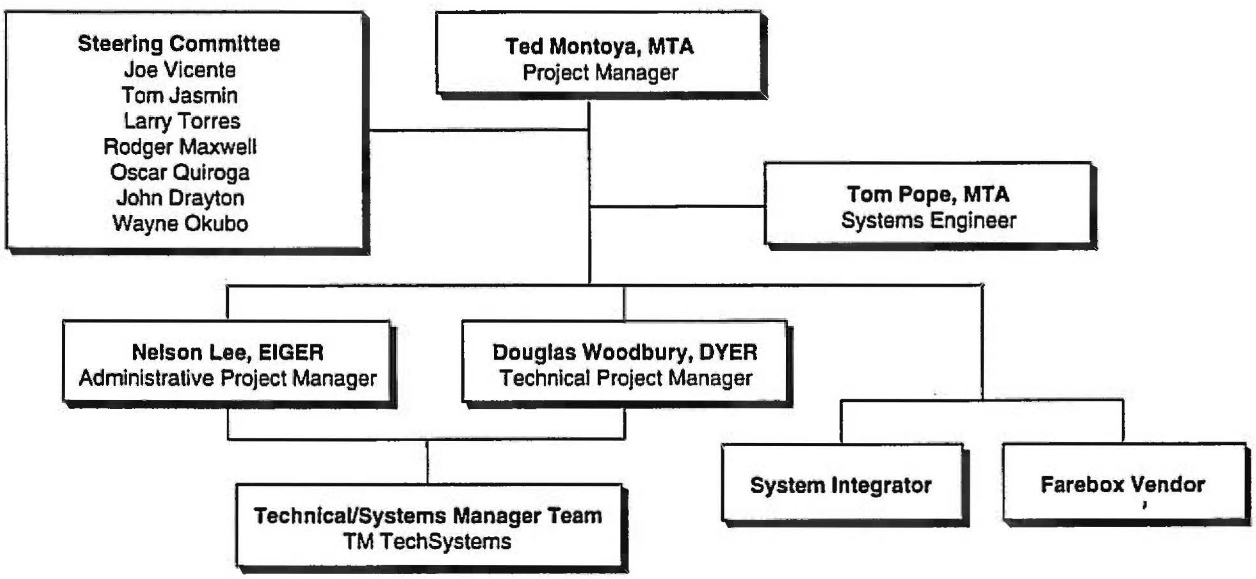
The implementation of ATMS is expected to be completed within three to five years. This time span includes the following tasks and estimated completion dates (ECD):

- Selection of a System Integrator, ECD 7/21/00
- Implementation and acceptance testing of the Core ATMS, ECD 7/28/02

- Implementation and acceptance testing of the Fully Integrated ATMS, ECD 1/15/04.

Adherence to this schedule will require a dedicated ATMS Team working closely together and meeting regularly. The team will be composed of: ATMS Project Manager, ATMS System Engineer, ATMS Steering Committee, System/Technical Support Manager Consultant Team, System Integrator, and UFS vendor as shown in Exhibit 6-1. Once the Integrator is under contract, office space in the Gateway building should be provided for the Integrator. A strong on-site presence will be crucial for quick resolution of issues that will crop up.

Exhibit 6-1. ATMS Team Organizational Chart



The current ongoing tasks for the ATMS project are completion of the Business Plan Report and the ATMS Conceptual Design Document. The conceptual design for ATMS is based on the information gathered for the business plan and is being developed nearly concurrently with the business plan. Both documents will be completed in April 2000.

Upon acceptance of the Business Plan and ATMS Conceptual Design Document, a technical specification for ATMS will be prepared. The technical specification will be based on the business plan, conceptual design, ATMS technical specification developed in 1998, SRRPS Reports, farebox specifications, and APC specifications. The TM Team will assist MTA personnel in the process of selecting and procuring the services of an integrator. Selection of the integrator will be completed in July 2000.

Once the Integrator is under contract, a kickoff meeting will be held to create a detailed schedule and detailed plans for the implementation of ATMS. Implementation of ATMS will be accomplished in two phases: Core System, Fully Integrated System. During the first phase, the integrator will procure, and implement a new radio subsystem for voice and data, Computer Aided Dispatch subsystem, AVL subsystem, APC subsystem, AVA subsystem, and develop an interface to smart fareboxes. Testing of the first articles for each bus type will completed in October 2001. Testing and acceptance of the Core System for the entire fleet will be completed in July 2002. During the second phase, the integrator will procure and implement a video subsystem. The Integrator will also develop an interface to a bus vehicle health monitoring system that will be procured with the buses. Completion and acceptance testing for the first articles and full fleet of the Fully Integrated System will be completed in September 2002 and January 2004, respectively.

TRS must be maintained and supported until the Core System has been completed and accepted. Details of the cutover plan from TRS to ATMS will be established during the kickoff meeting with the integrator. During the cutover period, the controllers will use both TRS and ATMS workstations during the final phases of the implementation of the core system.

The ATMS radios will be installed first in the new buses and the buses with the GE UCAD radios. These radios will initially be programmed to operate on the GE radio system. Once the radio system backbone for ATMS is completed, testing of the ATMS system will begin with the first article buses, installed with ATMS radios. Once the radio system has been validated, the buses with ATMS radio installed will be reprogrammed to operate on the ATMS radio subsystem. The ATMS radio subsystem will operate on the radio channels formerly allocated to the GE radio system. Installation of ATMS radios will begin in the TRS equipped buses when all of the GE UCAD radios have been replaced. The radios installed on the TRS equipped buses will be programmed to operated with the ATMS radio system. Thus, the radio channels assigned to the TRS system will be switched gradually to the ATMS system as the number of TRS radios decrease.

scheduling information from transit operators, freeway conditions from Caltrans, and major arterial traffic conditions for Los Angeles and Ventura County and make it available to information service providers and the traveling public. The MTA is currently developing a business plan as part of the LA/Ventura ATIS project to establish revenue and cost sharing principles with the information service providers.

When fully implemented, ATIS may provide traveler information to the general public via an Internet website and several strategically located kiosks. The format and layout of the web page (which is also displayed by the kiosks) have not yet been determined. A needs assessment and high level conceptual design is currently being developed. ATMS's ability to collect and provide real time vehicle locations and anticipated arrival and departure time data to ATIS may impact the development of the ATIS web page. ATMS will include capabilities for future expansion for ATIS applications, but support for ATIS is not within the current ATMS scope.

2.3.2 Bus Signal Priority

The MTA is currently conducting a pilot program to determine the viability of Bus Signal Priority (BSP). Crenshaw Blvd has been selected as the corridor to evaluate BSP. The BSP project is currently determining the technologies to use for the pilot program. Most likely, the implementation will not use a loop-transponder detector system, and will use a distributed system with a GPS vehicle location subsystem, onboard processor, and wireless transponder to request priority at an intersection. The planned BSP implementation will be designed for future interface with ATMS, whereby signal priority equipment from the BSP project may be integrated into ATMS. While ATMS will include provisions for future expansion to include BSP applications, support for the BSP project is not within the current ATMS scope.

2.3.3 Rapid Bus

In conjunction with the City of Los Angeles Department of Transportation (LADOT), the MTA is implementing a demonstration program to provide a new, fast, high quality bus service in selected corridors. The Metro Rapid Bus Program is designed to provide high-speed bus service by reducing the delay caused at bus stops and traffic signals. In Phase I of the program, Rapid Buses will incorporate a variety of methods intended to increase the speed and convenience of the service, including infrequent stops, frequent headways, special stations with "next bus" displays, and signal priority. Attributes planned in Phase II include fare prepayment, multiple-door boarding and alighting, and use of high capacity buses.

ATMS may interface with the Rapid Bus Program through the traffic signal prioritization system and passenger information displays. As control of traffic signals is under city jurisdiction, LADOT has implemented a loop-transponder detector system on several corridors to help determine when traffic signals should be changed. Loop detector transponders will be installed on the Rapid Buses to communicate with the underground loops to signal a bus arrival. Additionally, next bus arrival times will be conveyed in real-time to riders waiting at Rapid Bus stations. In the future, signal priority equipment and next bus arrival information may be integrated into ATMS. While ATMS will include provisions for future expansion to include Rapid Bus applications, support for Rapid Bus is not within the current ATMS scope.

2.3.4 Universal Fare System (UFS)

The MTA is undergoing preliminary design specification development for the Universal Fare System. The system allows passengers to use the same electronic fare media, the Metrocard, in "seamless" journeys from one participating agency to another in the Los Angeles region. A Standard Regional Revenue Processing System (SRRPS) specification was developed as a means of unifying the equipment purchased by various agencies in the area. A regional task force is currently developing rules for a clearinghouse to coordinate the processing and distribution of monies collected through UFS. Together, UFS and SRRPS will provide transit operators in the region with an advanced fare collection system that can accept multiple forms of payments and be capable of accommodating future advances in fare technology. Moreover, the system will enable accurate revenue management and distribution among regional transit agencies.

With regard to ATMS, the key driver is the integration of UFS. To support the Metrocard and future open architecture "smart cards" that may be implemented, an electronic farebox will be installed onboard all transit buses. ATMS must be capable of interfacing with the farebox for data sharing, transfer and download.

2.4 RADIO LICENSING CONCERNS

The MTA is licensed by the Federal Communications Commission (FCC) for radio spectrum. These licenses allow the MTA to use radio communications resources to support the various activities required of a large public transportation organization. This spectrum is very valuable and needs to be properly managed and the uses carefully planned. The FCC is concerned with proper utilization of spectrum by incumbent users and the demand for additional spectrum to satisfy the growing needs of emerging wireless technologies. Congress has mandated that the FCC identify underutilized spectrum and auction it off to the highest bidder. The MTA has been a victim of this process in the past — the agency had licensed 800 MHz spectrum but did not construct a system in the allocated time and therefore lost that spectrum. This resulted in the lease of spectrum, at a substantial cost from a third party, when this spectrum was critically needed.

The following is a review of the current spectrum issues impacting the ATMS project. They are critical issues that have an impact on current and future systems. In planning for the replacement of the existing transit radio system with ATMS, proper planning and a clear direction in the utilization of the current spectrum and future acquisition of new spectrum is vital. As shown in the discussion below regarding the 700 MHz band, planning ten years in advance is needed to assure that the MTA will have spectrum allocated. The current regional planning process will allow future spectrum to be reserved for use, but it must be requested now.

2.4.1 FCC Re-farming Rules

Recent FCC rulemakings, known as "Re-farming," are dividing existing radio channels in half in order to double the number of channels. The MTA's existing UHF channels are grandfathered at 25 kHz bandwidth channels for the immediate future. However, these 25 kHz channels may start to be interfered with by systems placed in service on the channels 12.5 kHz offset from them. The FCC, through recent Orders regarding the Communications Act of 1996, has allowed existing licensees to continue to use their existing spectrum indefinitely. This situation could change in the future with further "clarifications" of the Communications Act.

Migration to 12.5 kHz bandwidth must be accommodated by new radios, The FCC has mandated that any radio introduced after 1997 be capable of operation on 12.5 kHz bandwidth channels. The MTA's current MASTR II and RANGR radios are not capable of 12.5 kHz bandwidth operation.

Re-farming also addresses a migration to 6.25 kHz bandwidth channels in the future. No currently manufactured radios meeting the MTA's requirements are capable of 6.25 kHz bandwidth operation. However, the FCC is currently accepting applications for licenses for these frequencies. All radios introduced after 2005 must be capable of operation at 6.25 kHz bandwidth.

Data rates for 12.5 kHz channels will be one-half of the raw data rate for 25 kHz channels. Data rates at 6.25 kHz will be further reduced to one-quarter of the rate used at 25 kHz. It is expected that 6.25 kHz radios will be all-digital and backwards compatible with wider bandwidth technologies. The MTA will make this change to correlate with the normal lifecycle replacement of ATMS radios.

Most of the 6.25 and 12.5 kHz channels that are offset from the MTA's licensed and leased channels have been licensed by other firms. This has been done as a strategy to stake their claim on the spectrum if and when the MTA vacates it. This preemptive strategy allows them to claim the adjacent channels whenever MTA reduces its bandwidth. They cannot successfully use the channels until then. They could construct on the channels and, through the interference created, cause the MTA to narrow its bandwidth occupancy. This effort would be very destructive to the MTA bus communications system if new radios capable of narrow bandwidth operation are not installed in the system.

2.4.2 MTA Licensed Spectrum Options

The MTA has several options for continued access to radio spectrum. The following is a partial list summarizing the most important options available to the MTA in planning future spectrum usage:

- Construct on existing channels and exercise diligent efforts to retain rights to spectrum originally leased.

- Use 12.5 kHz voice on the ten leased channels and eight existing licensed 470 MHz channels.
- Pool the six MTA licensed 460 MHz channels and users into the ATMS system, giving all the groups better access to voice communications.
- More efficiently use the twelve licensed channels at 900 MHz by establishing a county-wide system usable by bus, rail, public safety agencies and other users.
- Consider the use of CDPD, Ardis, BellSouth, Metricom or other commercial provider for data. This will free up the existing 470 channels for exclusive use for voice operations.
- Start planning for new spectrum allocations in the Public Safety 700 MHz band for voice and data.

2.4.3 Lease Issues on Ten 470 MHz Channel Pairs

The MTA now leases ten 470 MHz channel pairs. For a 25-year term of lease commencing in 1992, with 10-year renewal periods, cost to the MTA is $100.00 per day per channel. There are ten leased channels, resulting in lease costs starting at $365,000.00 per year, which escalate by the consumer price index each year. These lease costs will easily exceed $10 million over the term of the lease.

Bandwidth issues arise due to unclear definitions in the lease as to how much bandwidth each channel leased should be allocated, after the MTA is required to use 12.5 kHz. Some of the legal questions that arise are: Does the lease give the MTA rights to the same bandwidth, which would give them an additional channel? Or do they continue to pay the same lease charges while receiving one-half of the spectrum originally leased? What happens when the MTA is required to further reduce bandwidth to 6.25 kHz? Should the MTA continue to pay more for less and less? These issues must be addressed and clarified in the spectrum lease contracts.

2.4.4 New 700 MHz Public Safety Allocation

The MTA has applied to the 700 MHz Regional Planing Committee for future spectrum for use by both voice and data systems. Availability issues will delay access to this spectrum for five to ten years in the Los Angeles area. This is due to current TV station occupancy of some of the spectrum, which encompasses channels 63, 64, 68 and 69. A TV station can remain on the air after the digital broadcast conversion deadline in 2007, if a survey shows that at least 20 percent of the households in the service area cannot receive digital signals. There may be an acceleration of this process caused by spectrum auctions for this bandwidth to be held in April 2000. The successful bidders for this spectrum may buy out the incumbent broadcaster, so that their new technology can be deployed earlier. This may benefit the adjacent public safety allocation, if the successful bidder deems it necessary to clear the adjacent channel broadcasters as well.

Wideband data allocations are available in this band. 50, 100, 150 and 200 kHz channels with data rates of 384 Kbps can be licensed. The FCC is mandating 2.56 bits per Hertz minimum efficiency, while the current best available efficiency is 1.2 bits per Hertz.

There are still many other issues yet to be resolved to the point where the FCC will accept license applications. No standards are yet agreed to, interoperability issues for voice and data need to be approved, regional planning committees have only been formed for less than six months. These and other factors will delay availability even in areas not impacted by incumbent TV stations.

It is very important that the MTA continue to participate in the process and reserve spectrum through the regional planning committee. In this way, when licensing can commence, the agency will have reserved a place for future expansion and implementation of future technologies.

2.4.5 Licensed Spectrum Summary

Properly configured, the MTA has sufficient frequency resources to handle near term voice and data needs. Reserving spectrum at 700 MHz will give a path for future needs and leasing spectrum, by the channel or by the bit, can be used to alleviate configuration inefficiencies and provide special needs such as very large data files and live video.

Given the frequency resources that the MTA already has and accounting for the needs of the various groups of users currently occupying them, better use could be gained through pooled use. A trunked voice radio system could satisfy the needs of groups with very different needs and give them better access. A private data radio network can handle large amounts of data serving many hosts and their user groups. A public network like CDPD has lower capital costs, but much higher operating and maintenance costs, because the user is paying someone else to maintain the infrastructure.

2.5 OTHER CONSIDERATIONS

The MTA's bus operators, controllers and mechanics are unionized, and labor contracts are renegotiated periodically. During this negotiation process, any new actions required of personnel must be identified and discussed. If, for example, ATMS requires a bus operator to perform more functions in order to do his or her job, then the added requirements must be negotiated as part of the new labor contract.

Since ATMS is intended to help improve operational efficiency, it must simplify personnel requirements, not make them more complex. In fact, ATMS should be designed to automate much of the work that is now performed manually by operators, controllers, maintenance personnel and other staff. In particular, ATMS will eliminate or simplify many of the data collection, analysis and reporting demands on MTA staff. For example, ATMS will reduce multi-tasking requirements for bus operators by eliminating the need to make stop announcements through AVA and simplifying fare and transfer handling through UFS. ATMS will reduce the effort needed by controllers to fill out Incident Reports by providing some of the information automatically through the CAD system. ATMS will reduce the time needed by mechanics to diagnose problems by transmitting fault codes indicating the nature of the problem.

The interface with ATMS, whether it is the driver control head on the bus, a controller workstation or a diagnostic laptop, must be designed to be user-friendly to minimize training needs. By making ATMS interfaces easy to use, the need for specialized skills or personnel qualifications is reduced.

3.0 DECISION CRITERIA

ATMS will provide the MTA with the tools and data to better manage its bus operations. However, the cost of installing and supporting ATMS is considerable, and risks do exist. The MTA and its contractors are prepared to address and minimize these risks.

3.1 PRIORITIZATION OF NEEDS

Due to funding and schedule constraints, it will not be possible for the MTA to configure ATMS to meet all of its goals and objectives immediately. Instead, the MTA's needs must be prioritized to assure that the most critical requirements are met first. The remaining available funding should be applied to components that will yield the greatest benefits for their costs.

The MTA has assembled an ATMS Steering Committee, comprised of seven key department managers whose responsibilities would be directly affected by ATMS. In conjunction with the ATMS project manager and systems engineer, the Steering Committee has and will continue to help guide and make strategic decisions throughout the project. The Steering Committee has established the goals and objectives for ATMS and will work with TM Techsystems and the System Integrator to achieve them.

The Steering Committee has determined the most critical needs are an enhanced radio communication system and a vehicle location system. Integration of ATMS with the Universal Fare System and a passenger counting system were also identified as priorities. Additionally, the Steering Committee has added automatic voice annunciation for ADA compliance as a priority in the first phase of implementation. Vehicle health monitoring and video surveillance will be implemented in the second phase.

3.2 RISK AND READINESS

There are two main sources of risk inherent in ATMS or any other technology-based project. The first risk is the possibility that the agency may not be prepared to properly implement and support ATMS. The second risk lies in committing to technology that may become obsolete. As demonstrated in the following paragraphs, the MTA is addressing these risks through:

- Identification and awareness of the risks
- The business planning process
- Implementation of effective training and continuous quality improvement (see Section 4.5)
- The ongoing actions of the ATMS Steering Committee.

Through this program, risks will be dealt with in a direct manner and therefore mitigated proactively.

3.2.1 Organizational Risk

Through the interviews conducted to support this business plan, the TM TechSystems Team has found several areas where the organizational structure and culture of the MTA could create impediments to efficient implementation of ATMS. These areas include:

- Lack of close coordination between functional groups, resulting in duplication of efforts — for example, there are presently four geographic information databases in use at the MTA.

- Resistance to open sharing of information.

- Tendency to react to crises rather than proactively trying to fix problems before they reach crisis levels.

MTA managers are aware of these tendencies and are striving to overcome them. To mitigate the risk, the ATMS Steering Committee and TM TechSystems are attempting to reach out to each group that is affected by ATMS so that these "stakeholders" can provide input to help shape ATMS to meet their needs. This communication also helps to promote "buy in" of each group to the benefits of ATMS, which will facilitate subsequent cooperation and coordination during the transition and implementation periods. Maintaining a high profile for ATMS with upper level management, particularly during implementation and start-up, will also help mitigate organizational risk. This increased awareness can help assure that resources needed to support the successful implementation of ATMS are committed.

3.2.2 Technical Risk

The MTA is proceeding before standards have been accepted for integrating the various ATMS hardware and software elements into one functional system. To mitigate this risk, ATMS specifications will be prepared to require use of open architectures that are based on published standards, with full documentation provided to the MTA. This approach has been used successfully in development of systems similar to ATMS at other agencies and will be refined based on the lessons learned by these other agencies.

Nationally recognized standards are needed to ease system integration and promote interoperability and regional sharing of information. The U.S. DOT is leading the development of standards for ITS projects, having identified 17 critical standards that are expected to be in place by January, 2001. These critical standards cover vehicle location referencing, data dictionaries, message set templates, and other important aspects of ITS system development. ATMS will utilize a blend of these emerging standards and de-facto standards for off-the-shelf solutions and existing systems to mitigate this technical risk in a cost-effective manner.

The U.S. DOT-sponsored Transit Communications Interface Profiles (TCIP) project was started to develop a family of standards specific to Transit ITS that would become part of the National Transportation Communications for ITS Protocol (NTCIP). The TCIP committee and subcommittees have developed drafts of a number of standards for data flow to support transit business practices, including a recent draft standard of fare collection objects. More recently, TCIP standards have converged with Society of Automotive Engineers (SAE) standard J1708T. A working group has been formed to develop a single standard for acceptance by the International Standards Organization (ISO). In addition, the data dictionaries that were developed under TCIP are recommended standards of the NTCIP.

However, the use of these draft and emerging standards is tempered by the reality of equipment availability. Few pieces of equipment on the market today have the TCIP protocols implemented. In fact, many large System Integrators appear to have a "wait and see" attitude concerning the roll-out of equipment with TCIP standards.

By proceeding now and with the installed equipment base onboard its buses, the MTA will likely be using multiple protocols to accommodate the variety of equipment that must be integrated for ATMS. This introduces a technical risk in that the MTA must rely on multiple vendors to work together to develop a cohesive, integrated system. Careful specification and management of each vendor's responsibilities must therefore be maintained throughout the project. The choice of component vendors may also be limited to those that are willing to cooperate with each other.

Another technical risk faced by the MTA is premature equipment obsolescence. Due to evolving technical standards and continuous, rapid advances in technology, the equipment procured now for ATMS will eventually become obsolete. New technologies and systems will emerge with superior functionality, performance, cost and reliability characteristics than those available today. This reality should be recognized by the MTA. While obsolescence cannot be avoided, it will be planned for in the ATMS specifications. The ability to replace portions of ATMS, without requiring a full system change-out, will be safeguarded by utilizing a modular design approach, with interfaces based on standards that are fully documented.

4.0 ATMS NEEDS ASSESSMENT

This section summarizes functional requirements for ATMS. The discussion of this section is intended to be high-level, focusing on the MTA's needs for ATMS. A more detailed discussion of system design requirements may be found in the Conceptual Design document, which will be prepared based on the findings of this business plan.

4.1 METHODOLOGY

To compile this needs assessment, the TM TechSystems Team interviewed the MTA managers and staff shown in Exhibit 4-1. A summary of the information garnered during these interviews was compiled as a separate document. Moreover, the Team held a briefing on ATMS for the MTA's Executive Officers for the purpose of informing them about the project and soliciting their feedback.

Exhibit 4-1. List of MTA Personnel Interviewed for the ATMS Business Plan

Interview and Subject Area
• Steve Lantz – Universal Fare System
• Rodger Maxwell – Automatic passenger counters
• Joe Vicente, Tom Jasmin and Oscar Quiroga – Transit Radio System
• John Drayton – Automatic voice annunciation, video surveillance and health monitoring system
• Tom Pope – ITS specifications for new bus procurement
• Mark Beauchamp, Mary Powers and Peter Serdienis – Automatic voice annunciation, video surveillance and health monitoring
• Patrick Soto – Geographic databases
• Oscar Quiroga – Radio recommendations
• Focus group of 8 Bus Controllers – Controller workstations
• Captain Vance Proctor (Los Angeles Police Dept. Transit Division) – Security issues
• Ellis Kyles and Joe Vicente – Mobile dispatch center and controller functions
• James Falicki – Assignment and labor tracking system for bus operators
• Peter Liu and Danny Wu – IMAJINE and ATIS
• Ellen Blackman – ADA compliance
• Captain Marc Klugman (Los Angeles County Sheriff Transit Services) – Security issues
• Bus Operators at Divisions 1, 2, 3 and 10 – Radio and dispatch support
• Grace Golden – Bus driver training
• Frank Cardenas and Don Stiner – Executive office issues
• Shahrzad Amiri - Bus signal priority issues

During each of these interviews, the Team attempted to gain a better understanding of the MTA's existing operations — what areas work well now and what areas need to be improved. The Team also attempted to gain a better understanding of ongoing projects that included a trial of the technologies to be included in ATMS or that may interface with ATMS in the future. Furthermore, interviewees were encouraged to discuss requirements, desires and constraints for ATMS.

4.2 GENERAL SYSTEM DESIGN AND PERFORMANCE REQUIREMENTS

Overall, ATMS should be designed to have the following characteristics:

- Open architecture to easily accommodate new components that may be added in the future
- Integrated but separable functionality (will perform its communication functions even when equipment supporting other functions is inoperable)
- High reliability
- Easy and low cost maintenance
- Easy to use with simple and intuitive personnel interface.

Additional discussion of each of these design characteristics is provided in the following paragraphs.

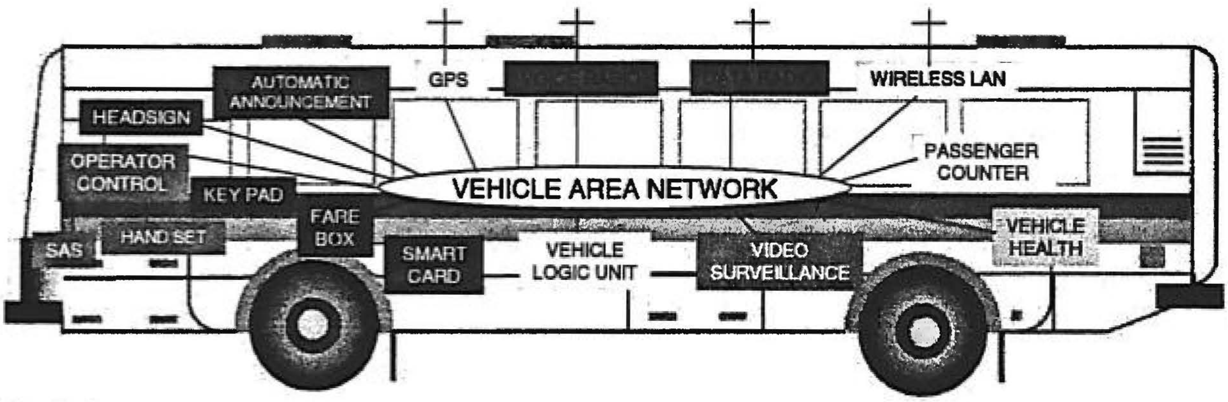
4.2.1 Architecture

With regard to onboard bus systems, ATMS should create a Vehicle Area Network (VAN), a backbone upon which components and subsystems could be installed and integrated (Exhibit 4-2). Ideally using non-proprietary communications protocols and standard software, each of these components should be able to "talk" to the main vehicle logic unit and to each other, with the information flow occurring through the VAN.

This approach provides a very flexible platform for ATMS in which components can be added as needs arise — and as funding and schedule permit. Furthermore, because none of the components are hardwired to each other, the failure of one component would not cause the entire system to fail. In fact, each component could be upgraded and replaced incrementally. Open systems compatible commercial-off-the-shelf components and software should be used to the maximum extent possible.

Off-board computer systems should be designed based on the same open architecture, modular design principles. A key requirement is that the software be easily modified, without having to hire the original developer, to conform with subsequent modifications and upgrades to ATMS. Additionally, the system must be sized to handle the throughput required without affecting system performance.

Exhibit 4-2. Conceptual Representation of a Vehicle Area Network for ATMS



Abbreviations:
SAS = Silent alarm system
GPS = global positioning satellite

It is envisioned that a Local Area Network (LAN) would be established for ATMS to link together the various computer servers that are needed to store and compile input databases, collect information, interface with controller workstations, create reports, etc. Access to the MTA's Wide Area Network (WAN) and the use of leased data services will also be needed to connect servers at each bus operating division and facilitate sharing of data throughout the agency.

4.2.2 Reliability and Maintenance

Reliability of the ATMS equipment should be such that it does not cause a measurable impact on overall service. Minimum acceptable levels of reliability should be established for each component that interfaces with ATMS. While it is not realistic to increase reliability since more components are being added, ATMS will attempt to maintain present levels of equipment reliability, at a minimum. ATMS itself is expected to have greater reliability than if its individual components were implemented separately, due to the effects of system integration.

The MTA should require the System Integration Contractor to provide sufficient spare parts and repair turnaround to ensure that reliability requirements are met throughout the life of the system and at no added cost to the MTA, except for normal replacement and repairs. Vehicle-borne equipment furnished under the ATMS procurement, and all equipment that is integrated with ATMS, should be capable of operating within the minimum mean time between failures, provided there is no abuse, vandalism, operation beyond standards, or lack of maintenance. Vehicle-borne equipment reliability should be vigilantly monitored due to the adverse environment specific to transit applications.

Usability standards and practices should be applied to both hardware and software. ATMS hardware should be designed such that installation of the components and system setup are efficient and error tolerant. ATMS components should be selected with consideration for the labor hours and cost needed for maintenance and replacement.

4.2.3 User Interface

ATMS components and their respective human-machine interfaces should be designed and tested to satisfy the users, including controllers, operators and maintenance personnel. The objective of the interface design should be ease-of-use. It should minimize training time and online support, while reducing the possibility of human error. Examples of user interface considerations include:

- Data entry keys/buttons
- Driver display screen/placement
- Graphical user interfaces
- Audible warnings and indications
- Tactile feedback during data entry.

ATMS software Graphical User Interface (GUI) should be designed with input from user focus groups. Since the users will be presented with real-time information and warning messages, it is critical that, for operational safety and system effectiveness, the software-driven interface is designed and tested with regard to ease of use. This would require that a representative sample of drivers, controllers and maintenance personnel be included in usability reviews through all stages of software GUI design. It will be a requirement of the technical specifications that the System Integrator work interactively with MTA representatives in detailing the GUI; however, the implementation schedule for ATMS precludes an extensive development cycle.

Design of the ATMS driver control module should allow the bus operator to easily and intuitively interact with the interface during normal operation. Several design requirements should be considered:

- Driver display should be easily readable in all light conditions (i.e., adjustable contrast, back lit)

- Effective operation of keys/buttons during all light conditions (e.g., direct light, glare, low light, etc.)

- Keys/buttons should have tactile and possibly audible feedback

- Keys/buttons size should be designed (e.g., size, shape, color, etc.) to reduce input errors

- Audible indications and warnings should be limited to only critical functions (limited to five different sound types)

- Angle of display shall be usable by drivers of different body dimensions.

Driver control module display information should be concise due to physical display limitations. Messages to the driver should be brief yet descriptive enough to allow for easy comprehension. Messages and warnings should be evaluated for information effectiveness and length, and tested with regard to user speed and accuracy performance. Additionally, the software screen flows should be reviewed with regard to human factors considerations, for example, menu logic, color coding, readability, error messages, boundary conditions, recoverability, etc. Drivers will not be expected to enter lengthy character strings or function sequences.

4.3 REQUIREMENTS, DESIRES AND CONSTRAINTS FOR SUBSYSTEMS

In addition to the overall system functionality, the TM TechSystem Team has developed criteria for each major subsystem or component of ATMS. These criteria are discussed in the paragraphs below.

4.3.1 Voice and Data Communications

Voice and data communications to support ATMS require two separate technologies. Voice will be supported by a trunked simulcast wide area system. Data will use a dedicated infrastructure consisting of a private data network or a public data network such as AT&T's Cellular Digital Packet Data (CDPD) system.

Voice Communications

Voice communications with the bus fleet is identified as a primary role of the ATMS communication system. The voice system should be independent of the data system, giving a high confidence level to operators and controllers that they can communicate via voice when the data network is inoperative. This approach will allow both voice and data communications to be optimized with the best infrastructure for its particular function.

Presently, the MTA is using two radio systems — Transit Radio System (TRS) and the older GE UCAD. These two radio types use independent sets of frequencies from the available MTA channels. TRS operates in a mode called "transit trunking" in which channel selection is controlled by a central computer based on requests by controllers. The computer will automatically assign a channel for the controller to communicate with a bus; the controller does not need to know which channel is used. The problem with this approach is that it does not efficiently utilize available air-time on the channel. Once a channel is assigned, it stays assigned until the controller releases it, even if other controllers are waiting to use the channel.

The ATMS voice radio system will use a trunked simulcast or multi-cast infrastructure due to the limited radio spectrum licensed and leased by the MTA and the efficiencies of that technology. It combines the most efficient use of the existing channels, along with wide area communications from multiple sites, requiring no operator intervention to steer the bus radio to the proper site for communication with the control center. Using all of the UHF channels for voice traffic is the most efficient means available to the MTA for managing the change to the new system and assure access to a voice channel with minimal delays.

Interim Procurement

An interim procurement of 300 to 400 voice radios is also required to accommodate the additional buses being added to the fleet this year. ATMS specification sections will be used for the technical section of this procurement, modified as necessary to work with the existing TRS / UCAD System. The risk associated with this procurement is that the radio equipment may not be compatible with procured ATMS equipment.

The need to support three over-the-air protocols — GE UCAD, TRS and ATMS — during transition to the new system is a risk that must be carefully planned and closely managed. The ATMS technical specification will provide for a proposed plan to accommodate continuing operations during transition to the new system.

Data Communications

The objectives of the ATMS data radio network are to support fleet management and ITS elements such as AVL, AVA, APC, VHM, UFS and VSS. To accomplish the objectives of the ATMS system, two data systems are required, a WAN and a LAN. The wide area system is used to communicate with the buses throughout the service area, update the various systems on board the bus with near real time information and report on bus status to the fleet management system. The wireless local area system is used in the yards to provide batch uploads and downloads of data between the ATMS host and the bus systems.

Wide area data communications will be accommodated by using a multi-channel conventional private radio system or a public subscriber network such as CDPD. Technology in this area is changing and evolving every six months. The best approach is to acquire the most current technology that can be offered at the time of procurement, using a functional ATMS specification to allow the System Integrator to propose either approach.

CDPD Issues

CDPD service for data offers access to a public data network without the investment in infrastructure. According to AT&T, the data handling capabilities of the network in the Los Angeles area are designed to provide three times the subscriber capacity of other metro areas. This means that the MTA should have good access to the system.

The cost to subscribe to the system is variable from $16 to $49 per unit per month plus a $45 activation fee for government users. The rate will vary depending on the amount of data that must be transmitted, with the $49 rate for unlimited access. Given the projected usage profile for ATMS and its subsystems, the rate per bus is estimated to be the unlimited access rate of $49 per unit. CDPD radio modems designed for transit use are available for $600 to $1000. This is half of the cost of a vehicle radio modem for a private network.

By using CDPD, the MTA would be able to use all of its existing radio channels for voice, thus easing the delays now experienced by operators in communicating with controllers. During the transition period, CDPD could be used until all of the buses are converted to the new voice radio system. However, this approach has risks, including: 1) The MTA will lose control of the data network infrastructure, and 2) A commercial provider is focused on much broader objectives and profitability matters and not on bus operations.

Also, CDPD is being superceded with more advanced EDGE (Enhanced Data rates for Global Evolution) technology in two to three years. EDGE is rated for data transmission at a rate of 383 Kbps, compared to 19.2 Kbps for CDPD. AT&T states that it will support CDPD for at least five to seven years. However, the emergence of EDGE will necessarily shift the focus of any further expansion and support away from CDPD. The MTA can transition to EDGE at the cost of replacing ALL of the CDPD radio modems with EDGE units and paying a proportionately higher lease charge for the enhanced service. Risk could be reduced by negotiating a contract requiring the service provider to replace the CDPD hardware with EDGE radio modems.

As an alternative to AT&T's CDPD, other public data service networks are provided by ARDIS, Bell South IP (RAM Mobile Data) and Metricom (Richochet). These services are limited to the existing infrastructure that has been built over the last ten years, will not be substantially enhanced in their present forms, and are very mature systems running at data rates of between 4800 baud and 19.2 kB. Thus, if the MTA were to choose a commercial service provider for data communications, CDPD is the recommended plan.

Data Wireless LAN

A high-speed division wireless LAN will be used to batch upload and download data to the ATMS computer onboard the buses. This will be vital for GIS updates, maintaining accurate route, run and time point data, and capturing UFS, APC and vehicle health data as the bus enters the yard. The LAN will also provide a means to upgrade software and diagnose problems with the ATMS subsystems without visiting each unit in the fleet. This will provide substantial savings in manpower needed to support the ATMS.

Recommended System

The baseline cost presented in Section 5 of this business plan assumes that the voice radio system will be trunked simulcast and that the wide area data transmission will be via an MTA-owned data radio network.

4.3.2 Automatic Vehicle Location (AVL)

AVL is a core ATMS function, providing real-time vehicle location data. This data not only allows a vehicle to be located and tracked by bus operations dispatch but is also required by other ATMS components to function properly, including:

- Automatic Voice Annunciation (AVA)
- Automatic Passenger Counting (APC)
- Video Surveillance System (VSS)
- Universal Fare System (UFS)

- Vehicle health monitoring (VHM).

Vehicle location data is provided via a Differential Global Positioning Satellite (DGPS) system that utilizes a supplementary fixed receiver to determine error correction for the mobile receivers. The MTA's AVL system will use the combination of GPS, dead reckoning, fixed differential correction receivers, and an algorithm processed by the onboard computer. Interaction of these subcomponents is required to accurately determine vehicle locations when GPS signal integrity is lost due to blockage by urban structures and other obstructions.

An advantage of an onboard AVL solution is that it is updated and stored throughout vehicle service. Therefore, a centralized system is not required to constantly communicate with all vehicles. Because this data is only sent when requested (i.e., "exception reporting"), data channels are under less demand. Data derived from AVL can include:

- Route number
- Schedule adherence
- Location deviations
- Headway distances.

Vehicle location information is integrated with a Geographical Information System (GIS) database, and an accurate position of the vehicle is identified, in relation to the surrounding area, including stops. Since AVL system performance depends on accurate and managed data entry, waypoint acquisition of routes and stops will determine the accuracy of the AVL system. These routes and stops are constantly modified in the field for a variety of reasons (e.g., enhance route effectiveness, construction zone detours, etc.), and frequent updates are needed.

The GIS database requires vigilant management to ensure that it is also modified and updated to resemble the same information that is being acquired in the field. Because the DGPS and GIS subfunctions interface to determine a vehicle's location with relation to the actual surroundings, this information is critical for overall AVL system accuracy and effectiveness.

To insure that the GIS database used by ATMS is fully and accurately maintained, the MTA should utilize the ATMS GIS database as the prime GIS database for all applications: scheduling, planning, stops, customer information, APC, AVA, etc. While integration of the ATMS database with these existing MTA systems is not within the ATMS project scope, the GIS database will be specified to be an open, flexible system that can be used by MTA for other functions.

4.3.3 Universal Fare System (UFS)

UFS will be integrated with ATMS. Together, the systems will provide the MTA with a service-oriented fare collection methodology as well as advanced fare management and security capabilities. UFS and ATMS will share operator log-in and work assignment information and AVL data. ATMS will provide a means for UFS to download data, when requested and automatically within the bus yard.

Prior to integrating the two systems, several issues need to be addressed. Two of the most significant issues include procurement scheduling and the driver control module.

Currently, the UFS procurement schedule is approximately six months ahead of the ATMS procurement. UFS includes acquisition of ticket vending machines for the rail system, a regional point-of-sale network and regional revenue clearinghouse; it has separate and complex integration issues beyond the scope of ATMS. Therefore, MTA policy requires the UFS to be a separate procurement from ATMS. However, separate implementation of UFS and ATMS could present component integration issues. Furthermore, delay of either systems could have potential funding, political, and legal implications.

In order to minimize the risk associated with the scheduling of the two contracts and the risk of requiring some customization of control head data communications and user interfaces, it is recommended that separate ATMS and UFS control heads be utilized that are housed within a single control head enclosure. This approach also has operational advantages in that it eliminates the need for the driver to toggle between ATMS displays and controls and UFS displays and controls, and thus is more user friendly. This "component" control head approach has been assumed in the cost data included in Section 5 of this business plan.

4.3.4 Automatic Voice Annunciation (AVA)

AVA coupled with an onboard variable message sign provides both audible and visual notification of vehicle locations, routing, and next stop. Providing this information in two forms allows passengers with hearing or visual impairments the opportunity to be notified of critical transit information. Additionally, an externally variable message sign and speakers are needed to inform waiting passengers of the bus route and destination. AVA meets the requirements set forth by the Americans with Disabilities Act of 1990 and reduces multi-tasking requirements placed on the bus operator to manually announce this information.

AVA requires real-time vehicle location data from the AVL system integrated with accurate route and stop information derived from the GIS database. For AVA to function properly, it is critical to keep the database updated for any route modifications and stop changes.

AVA will include an interface to control the MTA's existing headsigns, based on operator-entered work assignments and vehicle AVL system. This will require some customization for the existing headsigns, since they are built by several manufacturers, but will reduce required operator actions.

AVA will provide announcements in the English language only, as per MTA policy. AVA is not recommended to include advertising, as there is concern that if advertising were included, it would cause passengers to not pay attention to the stop announcements. AVA will utilize existing public address equipment and will not provide additional amplifiers or speakers. It is assumed that the existing AVA equipment presently onboard 79 buses under the Talking Bus Program will be replaced under ATMS, in order to provide a common equipment set and database.

APPENDIX A: List of Acronyms

Mbps	Megabits per Second
MDU	Mobile Data Unit
MHz	Megahertz
MTA	Metropolitan Transportation Authority
NTCIP	National Transportation Communications for ITS Protocol
PRTT	Priority Request To Talk
PUC	Public Utilities Commission
RFP	Request For Proposal
RTT	Request To Talk
RTTP	Request To Talk to Police
SAE	Society of Automotive Engineers
SAS	Silent Alarm System
SCAG	Southern California Association of Governments
SEPTA	Southeastern Pennsylvania Transportation Authority
SMR	Specialized Mobile Radio
SRRPS	Standard Regional Revenue Processing System
SW	Software
TCIP	Transit Communications Interface Profiles
TRS	Transit Radio System
UFS	Universal Fare System
UHF	Ultra High Frequency
VAN	Vehicle Area Network
VDT	Video Display Terminal
VHM	Vehicle Health Monitoring
VSS	Video Surveillance System
WAN	Wide Area Network

ADA	Americans with Disabilities Act
APC	Automatic Passenger Counters
ATIS	Advanced Traveler Information System
ATMS	Advanced Transportation Management System
AVA	Automatic Voice Annunciation
AVL	Automatic Vehicle Location
BAFO	Best And Final Offer
BSP	Bus Signal Priority
CAD	Computer Aided Dispatch
CDPD	Cellular Digital Packet Data
CDR	Conceptual Design Review
CD-ROM	Compact Disc Read-Only Memory
CORBA	Common Object Request Broker Architecture
COTS	Commercial Off The Shelf
CPUC	California Public Utilities Commission
CQI	Continuous Quality Improvement
CRT	Cathode Ray Tube
DGPS	Differential Global Positioning Satellite
DOT	Department Of Transportation
DVD	Digital Video Disc
ECD	Estimated Completion Date
EDGE	Enhanced Data Rates for Global Evolution
EP	Equivalent Position
ESRI	Environmental Systems Research Institute, Inc. (GIS software)
FCC	Federal Communications Commission
FY	Fiscal Year
GB	Gigabyte
GE UCAD	General Electric Upgraded Computer Aided Dispatch
GIS	Geographical Information System
GPS	Global Positioning Satellite
GUI	Graphical User Interface
HW	Hardware
IR	Incident Response
ISO	International Standards Organization
ITS	Intelligent Transportation System
KB	Kilobyte
Kbps	Kilobits per Second
KCATA	Kansas City Area Transportation Authority
kHz	Kilohertz
LACMTA	Los Angeles County Metropolitan Transportation Authority
LAN	Local Area Network
LAPD	Los Angeles Police Department
LASD	Los Angeles Sheriff's Department
MARTA	Metropolitan Atlanta Rapid Transportation Authority
MB	Megabyte