INTERcity TRANSIT

FY2005 ITS DEPLOYMENT PROGRAM GRANT LOCAL EVALUATION REPORT

July, 2008

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1. Executive Summary

In April 2003, Intercity Transit, in Olympia, Washington, embarked on a project to improve its radio communications capabilities and add appropriate advanced transit technologies to assist in the management of its fixed route and Dial-A-Lift (Paratransit) operations and to enhance passenger services. Following a needs assessment study, which considered Intercity Transit's needs and required elements of the Thurston County Regional ITS Architecture, and the development of a project plan, a technical specification was developed for the procurement of an Advanced Communication System (ACS). Proposals were solicited, evaluated, and a contract executed with *Orbital TMS* in August 2005 for the implementation of the ACS. The system, which included an updated and expanded radio communications infrastructure and comprehensive CAD/AVL and Smart Bus technologies was implemented, installed, and tested, and subsequently accepted by Intercity Transit in September 2007.

In parallel with the ACS procurement, Intercity Transit was also in the implementation phase of a fixed route scheduling system by *The Master Scheduler*, and a paratransit scheduling system by *RouteMatch*.

A major goal of the ACS project was the enhancement of customer satisfaction, which was to be achieved through implementation of automatic audio and visual bus stop announcements, passenger transfer coordination, transit center bus arrival information, schedule information exchanges with regional transit providers, and enhanced Dial-A-Lift capabilities with improved manifest management and vehicle monitoring. Electronic exchanges of schedule information have not been implemented, but the other functions have been successfully implemented and are in full operation. Customer surveys, to be conducted beginning in late 2008, will help reveal the impact on customer satisfaction as a result of these enhancements.

Project implementation was relatively smooth and the specified functions are in operation. There were, however, a few issues related to the integration of ITS components and the implementation of ITS standards that were noteworthy and are summarized below for the benefit of others that seek to implement these technologies.

- The responsibility for data exchange interfaces with supporting systems needs to be documented and included in the appropriate contracts.
- Subject to external scheduling constraints, projects for new or upgraded fixed route or paratransit scheduling systems should be complete, or at least well underway, before the start of the ACS implementation.

- The implementation of interface standards (e.g., SAE J1708/1587) is not always consistent among equipment suppliers and must be carefully considered to ensure that the functions desired from the data exchange produce the desired results.
- Frequently, the implementation of interfaces with systems external to the agency can not be completed as planned because the external system is not prepared to handle the interface or the owner of that system is not interested in implementing the interface.

2. Agency Background

Intercity Transit is a Washington State Municipal Corporation responsible for providing public transportation services in a portion of Thurston County that includes the urban areas of Olympia, Lacey, Tumwater, and Yelm. Intercity Transit service is also provided along Interstate 5 into Pierce County to Tacoma. Intercity Transit provides service for 146,611 people in an area of approximately 97 square miles.

Operating out of the Pattison garage facility, Intercity Transit operates 22 fixed routes over 192,850 annual revenue hours with a fleet of 68 heavy duty coaches and 14 non-revenue vehicles. This fixed route operation serves over 900 bus stops, 3 Park-and-Ride locations, 2 Transit Centers as well as 3 transfer hubs. Intercity Transit routes offer coordinated transfers to connecting bus services provided by Pierce County, Greys Harbor and Mason Transit systems; and regional connections to Amtrak, Greyhound, and Sound Transit bus and rail services.

Intercity Transit also provides Dial-A-Lift, door-to-door van service to an area within 3/4 miles of the established fixed routes for ADA certified riders (paratransit) with a fleet of 31 Dial-A-Lift vans. Dial-A-Lift service is also provided out of the Pattison garage facility.

Intercity Transit also provides Vanpool services, which include commuter vans and ride-matching services to groups of at least five people who share a ride to work. Presently, 180 vanpools are operating in the program. Additionally, Intercity Transit provides “welfare to work” service termed “Village Vans”, which serves individuals on welfare/low income through an on-the-job training program and by providing transportation services. Three vans are dedicated to this service, which operates much like the Dial-A-Lift services.

The Pattison facility houses all Intercity Transit’s buses, vans, and support vehicles, along with the associated maintenance and operation facilities, radio dispatching facilities, and executive and administrative offices. The Customer Services division, which provides information to the public regarding all transit services in the area, is located at the downtown Olympia Transit Center.

Fixed route radio dispatch operations are conducted from the fixed route dispatch room located on the first floor of the Pattison facility. The Dial-A-Lift radio dispatch operations are conducted from the Dial-A-Lift dispatch room, also located on the first floor of the Pattison facility. One Dial-A-Lift radio dispatch position is located in this room, along with five telephone call-taker positions that are used for Dial-A-Lift reservation services.

Intercity Transit's radio communications system, prior to the implementation of the Advanced Communication System (ACS) under this project, consisted of three conventional 450 MHz UHF radio channels at two sites. The main site at Capitol Peak had repeaters for all of Intercity Transit's licensed frequencies, and a backup site at Crawford Mountain had a single repeater operating on the fixed route frequency. The equipment at these sites supported voice radio communications to buses and other transit vehicles in Intercity Transit's service area. These base stations operated in the repeat mode, with communications from the Pattison Facility to Capitol Peak and Crawford Mountain provided by control stations with rooftop antennas located at the Pattison Facility. The major portion of the radio system had been in service nearly twenty years.

3. Project Description

3.1 Project Background

Intercity Transit was part of the implementation team for the regional ITS Architecture project for Thurston County. Members included all local jurisdictions along with county and state emergency and transportation officials. A sub-set of the regional architecture was a Public Transportation System Architecture and Strategic Deployment Plan, which identified a sequencing plan for ITS element implementation.

In April 2003 a consultant was engaged to conduct a follow up study to explore the possibility of integrating transit and county public works radio systems. The study's conclusion in December was that the operational differences between the agencies made this impractical.

Intercity Transit then proceeded to conduct a further study of system needs, followed by preparation of the Advanced Communication System (ACS) Technical Specifications and RFP Documents for the acquisition of proposals. The acquisition process began in fall 2004, with award made in June 2005 and an implementation contract executed in August 2005.

Integration activities in this project included:

- Fixed route scheduling system data exchange with the ACS

- Paratransit scheduling system data exchange with the ACS
- Automatic vehicle location (AVL) data and computer aided dispatch (CAD) data linked together within the ACS for the management and monitoring of transit service
- AVL and scheduling data linked to transit center dynamic signage

3.2 Project Overview

Under this project, Intercity Transit acquired an Advanced Communications System (ACS) using Computer Aided Dispatch (CAD) and Automatic Vehicle Location (AVL) technologies to better manage its fixed route and Dial-A-Lift (paratransit) fleet operations. The ACS tracks the location of each ACS-equipped vehicle and presents the vehicle locations to centrally located dispatchers on a real-time map display. The ACS uses position data to monitor each vehicle's progress along its route and against its schedule, and alerts the dispatcher when a deviation is detected. The ACS also provides tools for the dispatcher to better manage mobile radio communications with the vehicles, including the means to communicate with vehicle operators via short text messages and Dial-A-Lift manifests, rather than tying up critical radio resources with voice communications.

The project consisted of a complete, operating ACS with all hardware, software, and services necessary to accomplish the supply, installation, testing, documentation, training, and startup of the complete system, including fixed-end equipment and equipment on-board vehicles.

The fixed-end equipment at the central site, including radio communications interface equipment and processors, is located in a newly renovated equipment room at Intercity Transit's Pattison Facility. The ACS supports full dispatch operations at the fixed route and paratransit dispatch offices. A remote, emergency, dispatch capability is also located at the Regional Emergency Services Center, operated by the Thurston County Department of Communications and Emergency Services.

The fixed-end equipment also includes radio communications equipment installed at the two base station sites, which includes base stations, combiners, multi-couplers, antennas, power supplies, and other related equipment. The on-board vehicle equipment includes mobile radios, radio handsets, radio modems, intelligent vehicle control units, vehicle control heads, vehicle area network (VAN), GPS receivers and antennas, and interfaces to other on-board systems (e.g., next-stop audio/visual announcement equipment, vehicle alarms, and automatic passenger counters).

The ACS enables reliable and efficient communications between the fixed-end equipment and the revenue and non-revenue vehicles for both the current and the defined expansion expected in the fleets and service area. The ACS obtains scheduling data from *The Master Scheduler*, a fixed-route scheduling system, and paratransit manifest information from the *RouteMatch* paratransit scheduling system.

Project implementation began with contract execution with the successful Contractor in August 2005, and was complete and fully operational by September 2007.

Early in the project, additional 450 MHz radio communications channels were acquired to accommodate data communications with the vehicles, and all channels licensed as narrow band to allow greater flexibility under evolving FCC requirements. Additionally the radio communications infrastructure was reconfigured and enhanced to provide full redundancy of both voice and data communications from the Capitol Peak and Crawford Mountain radio communication sites. New, microwave backhaul communications was established from the Pattison Facility to the Thurston County Emergency Services Center. From there, Intercity Transit leases excess microwave capacity from the county on their link to Crawford Mountain, and created its own link from there to Capital Peak.

The ACS uses the fixed-site radio system and on-board vehicle equipment (mobile radio and processor) to control two-way radio traffic and monitor service performance in real time. System information is uploaded from the existing fixed route scheduling software and paratransit scheduling and management software and used by the ACS fixed-end and on-board computers.

Fixed route transit buses have an on-board computer to manage communications and data relating to vehicle location and service performance. The computer provides bus location data for existing automated destination signs, and also triggers voice and text announcements of upcoming bus stops to passengers.

A hidden emergency alarm switch is provided in the driver's area to allow a covert alarm to be issued to the dispatcher in the event of a critical problem on the bus. This function also enables a dispatcher to monitor the sound on the vehicle through a microphone in the driver's area. The ACS's AVL capability enables reporting of the exact bus location, should emergency assistance be required.

Error codes (alarms) from select vehicle mechanical components are monitored and sent from the affected vehicle to the dispatcher and, for evaluation, to the vehicle maintenance personnel at the maintenance facility. This provides for better analysis of problems while a vehicle is on the road and reduces service interruptions.

Variable message signs have been installed at both the Olympia and Lacey transit centers, with the capability to expand this capability to other locations in the future. These signs receive vehicle schedule and location information, and display the projected departure of buses. This same information will become part of a future effort to integrate Intercity Transit's bus location data with a website application allowing customers to track the status of their bus over the Internet.

The ACS enables paratransit scheduling and management software to adjust automatically to changes in system utilization. This is expected to lead to improved ability to provide same day rides for paratransit program clients.

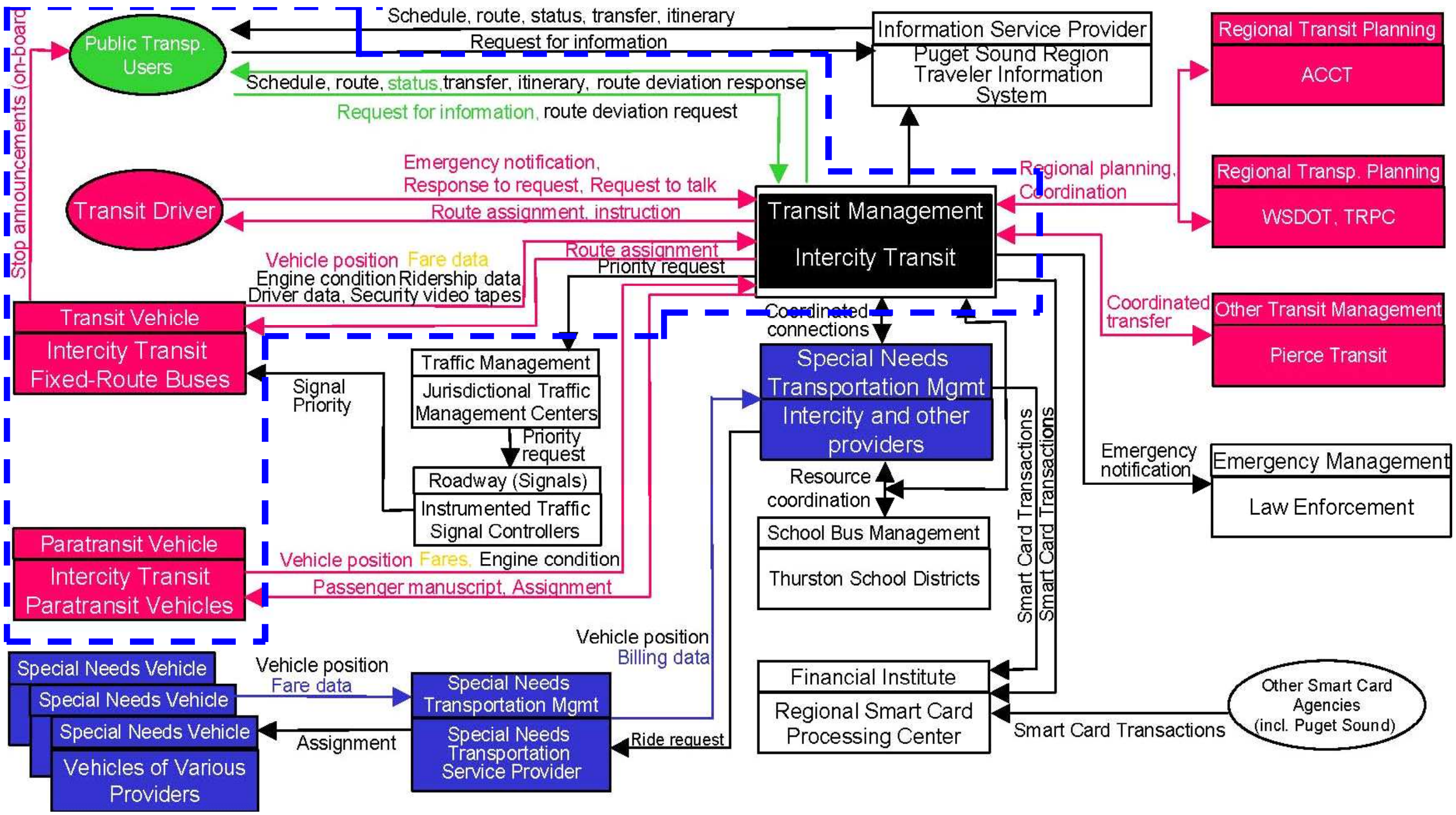
3.3 Consistency with the National ITS Architecture

The overall ACS project specifically addresses the Regional ITS Architecture, based on the National ITS Architecture and documented in the Thurston Region Public Transportation System Architecture and Strategic Deployment Plan (available at http://www.trpc.org/programs/transportation/its/index.htm). Figure 3.1 provides an overview of the Thurston Regional ITS Architecture. Elements of this plan specifically addressed in the ACS procurement include the following:

- **Transit Management Center** – CAD/AVL fixed end system components
- **Wide-Area Wireless Communications** – new radio system components to support CAD/AVL data communications with the vehicles and to improve voice communications
- **Public Transportation Users** – next stop annunciation and passenger transfer coordination on fixed route vehicles. Bus arrival information at selected bus stops and transfer centers. System status information via customer service.
- **Transit Driver** – Covert emergency alarm; operator login; data and voice communications functions
- **Transit Vehicle** – Route and Schedule Adherence tracking; mechanical alarms
- **Paratransit Vehicle** – Real-time (online) manifest assignment and update; arrival and completion status reporting, including fare data.

Additional ITS Standards included in the design of the ACS include a vehicle area network (VAN) that supports the SAE J1708/1587 standard and the use of NTCIP standards where applicable.

Figure 3.1 - Excerpt from Thurston Regional ITS Architecture



Near-Term Intercity Transit ITS Investments

- N-1: Communications System Study & CAD/AVL System w/APC's and Annunciators
- N-3: Registering Fare Boxes
- N-4: Demand-Responsive Passenger Information/Fare System
- N-5: Initial Real-Time Bus Status Information System & Transfer Coord.

4. Evaluation Plan

The sections that follow identify the project goals and other activities that were evaluated as part of Intercity Transit's self-evaluation and are presented in this Local Evaluation Report.

4.1 Project Goals

The primary and high priority goal to be achieved under this ITS Deployment Program grant was ***customer satisfaction***. Several of the system functions addressed in the project's Needs Assessment Report and the resulting Technical Specification developed as part of the procurement documents address this important topic.

The primary core elements of the ACS project, which included enhanced radio communications, computer-aided dispatch (CAD), and automatic vehicle location (AVL), provided the foundation for enhanced transit management functions, like route and schedule adherence, Dial-A-Lift (paratransit) manifest management, voice and data message communications, incident management, and vehicle alarm monitoring. In achieving these functions, the foundation was provided for several functions that directly address the riding customer and enhance customer satisfaction. These include:

- Automatic next-stop audio and visual messages on-board all fixed route buses
- Passenger transfer coordination
- Transit Center signs providing real-time bus arrival information – both visually and with on-demand audio for sight impaired customers
- Data exchange capability with other regional transit providers for coordination of services
- Increased capability to provide Dial-A-Lift rides on a same-day basis through improved manifest management and vehicle monitoring.

4.1.1 Customer Satisfaction

The evaluation of customer satisfaction can be difficult, particularly since the measurement of customer satisfaction yields a suspect metric. New features of the ACS system provide existing riders better control of their trip, but as these riders were already customers, in a competitive environment the real issue is "what can be done to attract new riders." With gas prices at record levels, identifying the specific cause of a change in ridership is difficult to determine. Therefore, a more meaningful measurement of how well the ACS meets the goal of customer satisfaction would be the satisfaction of customers who remain bus users.

4.1.2 Rating and Evaluation Strategy

In keeping with the goal of determining the level of customer satisfaction with the implementation of new technologies through the ACS, other than the potential increase in ridership that may result from other conditions (e.g., high gas prices), Intercity Transit will be conducting general market surveys beginning October 2008. While the surveys will include many of the items from previous surveys, specific targeted questions will be included that address new features provided by the ACS (e.g., stop announcements, transfers, etc.). Development of these surveys will address key topics related to *awareness of the new technology, usage of the new technology, and the customer's assessment of its value*. Reviewing these topics and changes to previous responses is expected to reveal changes in the level of customer satisfaction.

4.1.3 How Achieved/Not Achieved

The general customer surveys to be conducted in October 2008 will include questions relating to the new technologies provided by the ACS, and will be used to complete an evaluation of how well these new functions enhanced customer satisfaction.

Following the completion of the survey and evaluation of the results, Section 5 of this report will be updated to document the findings.

4.2 Additional Elective Activities

In addition to the local evaluation, a discussion of lessons learned concerning the technical and institutional issues encountered in integrating ITS components and experiences, challenges, and approaches used in achieving consistency with the National ITS Architecture and Implementation of ITS standards are also included with this Local Evaluation Report.

4.2.1 Lessons Learned on the Technical and Institutional Issues Encountered in Integrating ITS Components

The ACS project plan included the integration of ITS components, both within Intercity Transit (internal) and with other agencies (external). Both of these levels of integration presented challenges and had affects on project implementation.

4.2.1.1 Integrating Intercity Transit Internal Systems

Internal system integration, which could be considered within the ***ITS transit management component***, consisted of the following major activities:

1) **Fixed route scheduling system data exchange with the ACS**, which included extensive data exchange between a newly acquired fixed route scheduling system and the ACS to provide the current schedule and bus stop data to the ACS. This was required for real-time vehicle monitoring functions. This is a one-way data exchange from the scheduling system that provides the basis for route and schedule adherence and provides important information to both the dispatcher and driver.

2) **Paratransit scheduling system data exchange with the ACS**, which included extensive data exchange between a newly acquired paratransit scheduling system and the ACS to provide real-time paratransit manifest information to the vehicles and acquire trip status from the vehicles. This is a two-way data exchange that enables the dispatcher to monitor and add/delete trips and enables the driver to be cognizant of their work as it may change throughout the day.

3) **Automatic vehicle location (AVL) data and computer aided dispatch (CAD) data linked together within the ACS for the management and monitoring of transit service**, which provides for tight coordination between the two functions within the ACS. This enables the dispatcher to seamlessly acquire AVL data while performing a CAD function and to perform CAD functions from AVL displays. This linkage is most clearly observed in the event of an emergency vehicle alarm, where receipt of an alarm (CAD) automatically initiates a specific AVL display identifying the vehicle issuing the alarm. This integration is largely within the ACS system itself and was covered under the specifications.

4) **AVL and scheduling data linked to transit center dynamic signage for customer monitoring of service**, which included data exchange between the ACS and transit center signs to provide real-time bus arrival information for customers at the transit centers. As with the CAD/AVL integration, this data exchange is within the ACS system, but does require connectivity between the fixed site equipment at the Pattison Facility and the transit centers.

4.2.1.2 Integrating External Systems

External system integration, which could be considered within the ***ITS regional multi-modal traveler information component***, consisted of the following activities:

1) **AVL and scheduling data linked to transit center dynamic signage for customer monitoring of service**, which is the same as previously presented under Section 4.3.1.1. It is added here only to indicate that the function is also considered to be part of the traveler information component. These real-time displays of vehicle status at two major transit centers has demonstrated the functional capability, and the anticipated survey to be executed at the end of 2008 will determine whether the information is found to be usable and valuable to customers. Extension of this feature is desired for other major transfer locations without high speed (T-1) connections, but at the time of this writing the use of existing radio frequency transmissions is still being developed.

2) **AVL and schedule data exchange with Advanced Traveler Information System and Trip Planning System**. Intercity Transit plans to utilize the GPS-generated location information for a future trip planning program on its Internet site, but implementation of this activity has not yet been scheduled. Additionally, the ACS enables Intercity Transit to provide schedule information to regional transit agency systems (Sound Transit and Pierce Transit) and provide schedule signage at connecting transit agency facilities, but at this time, these systems and facilities are not prepared to accept this data.

4.2.2 Lessons Learned on the Experiences, Challenges, and Approaches Used in Achieving Consistency with the National ITS Architecture and/or Implementation of ITS Standards

The ACS project has included several instances where conformance to standards had an affect on the design and ultimate implementation activities. For the most part, these issues related to the use of the SAE J1708/1587 protocol for the Vehicle Area Network (VAN).

4.2.2.1 J1708/1587 Interface Protocol Issues

The procurement specifications required the contractor to implement a Vehicle Area Network (VAN) based on the latest version of the J1708/1587 standards and, where possible, use that interface standard for data exchange between the ACS on-board processor and other onboard equipment/systems provided by other suppliers. Under the final design, this integration included data exchange between the vehicle engine and transmission systems, the farebox equipment, and the destination sign systems. Other potential subsystems included the Automatic Passenger Counter (APC) subsystem and the onboard audio and visual next stop announcement subsystem, but these were provided by the ACS contractor with interfaces addressed internally within the ACS system.

1) **Vehicle Engine and Transmission monitoring and diagnostics**, which includes monitoring of engine and transmission status alarms and reporting these vehicle alarms to the dispatcher and maintenance supervisor. This is a one-way, real-time data exchange from the vehicle to the fixed-site system that, in addition to the specific alarms (e.g., high coolant temperature), reported the measured “value” data (e.g., actual temperature).

2) **Farebox data exchange and alarms**, which includes the monitoring and reporting of specific farebox alarms (e.g., tamper) from the vehicle to the fixed-site system and the exchange of ACS data from the onboard ACS vehicle subsystem (e.g., logon and vehicle location data) to the farebox.

3) **Destination sign interface**, which provides the appropriate destination sign codes for the specific route to the sign subsystem. This is a one-way data exchange from the onboard ACS vehicle system to the destination sign subsystem, based on the vehicle logon data.

5. Evaluation Findings

5.1 Project Outcome

While the final results of a measure of customer satisfaction have not yet been completed (survey work will begin in late 2008), the functions planned to address the customer needs (Section 4.1) have been successfully developed and implemented, and are presently in full operation. Several of these functions are enabled through implementation of automatic vehicle location technology, but they still frequently require fine tuning for accuracy and reliability. Such was the case for the ACS as described with the functions below:

- **Automatic next-stop audio and visual messages on-board all fixed route buses:** Audio and visual messages required thoughtful development by Intercity Transit to ensure that they were clear, understandable, and occurred at the proper location. During initial rollout of this function, it was necessary to monitor buses en route to ensure that each specific message was correct for the bus stop and occurred at the proper time. In some cases, messages had to be shortened or activated earlier along the route. These actions are normally required, and agencies should consider the time and effort that will be required by its staff, and possibly consider a rollout of the function in limited phases to prevent announcements that are incorrect to continue for a long period while others are being corrected.

- **Passenger transfer coordination:** This function has been implemented to assist passengers who whish to transfer to another route – a function that was previously performed manually by the bus operator when requested by a passenger. Following rollout of this function, it was necessary for Intercity Transit to investigate cases of transfer rejection by the system to ensure that the automated decision was correct for the specific conditions. The algorithm includes several adjustable parameters that affect the decision whether a transfer can be completed without affecting service. Work continues to fine tune the system as individual system responses are tested for expected reactions to various issues. The follow-up survey will identify customer satisfaction with the results of this function, and whether more adjustments are necessary.

- **Transit Center signs providing real-time bus arrival information – both visually and with on-demand audio for sight impaired customers:** As with stop announcements, the audio and text for these information signs required thoughtful development by Intercity Transit. Additionally, consideration was required concerning how bus departure time should be presented. Following rollout of this function, a thorough review of the data presented throughout the day was necessary to ensure that it was correct and meaningful to customers. The audio announcements are computer generated, and required field review of each potential announcement for understandability.

- **Data exchange capability with other regional transit providers for coordination of services:** As described earlier (Section 4.2.1.2.2), this function has not yet been implemented because the receiving systems and sign locations are not prepared to accept the Intercity Transit data.

- **Increased capability to provide Dial-A-Lift (paratransit) rides on a same-day basis through improved manifest management and vehicle monitoring:** This function requires close coordination between the ACS and the Dial-A-Lift scheduling system, both of which were new procurements. Presently, the ACS is complete and capable of handling the exchange of electronic manifests to the vehicles. However, slow resolution of critical issues with the scheduling system delayed the switch from paper to electronic manifests. Conversion to exclusive use of paper manifests only recently occurred. Assessment of improved manifest management is only beginning. The recent addition of

Integrated Voice Recognition capability is expected to further enhance Intercity Transit's Dial-A-Lift program.

5.2 Lessons Learned Report

Specific lessons learned during the execution of this ACS project as they relate to the integration of ITS components and achieving consistency with the National ITS Architecture are addressed in Sections 4.2.1, 4.2.2, 5.4.1, and 5.4.2.

Additionally, lessons learned that apply generally to the execution of all high technology projects, like the ACS, included the thorough application of the concepts identified below. These concepts were followed by Intercity Transit and enabled the implementation of an Advanced Communications System that met the identified needs for the contracted cost and near the contracted schedule.

- **Comprehensive Planning** – which established Intercity Transit's goals and needs for the ACS project, the estimated costs, and the implementation plan
- **Technical Specifications** – which established the contract requirements for the ACS and the activities and responsibilities of the Contractor while implementing the system
- **Thorough Evaluation of Proposals** – to determine the proposal that was is in the best interest of Intercity Transit with regard to the Contractor's capabilities and experience, the requirements, and the resulting cost and schedule
- **Development of a Contract** – which held the Contractor to the requirements of Intercity Transit's terms and conditions and the ACS technical specifications
- **Effective Project Management** – during which Intercity Transit provided the data required by the Contractor for the development of the system and database. The specified requirements enabled Intercity Transit to comprehensively monitor and review all project activities through meetings, document reviews, comprehensive design reviews, participation in testing activities, and installation coordination.

5.3 Institutional Issues

Institutional issues related to the integration of ITS components that were encountered during the implementation of the ACS are described in Section 5.4.1.2.

5.4 Findings from the Additional Evaluation Activities

5.4.1 Lessons Learned on the Technical and Institutional Issues Encountered in Integrating ITS Components

The planned integration of Intercity Transit internal ITS components was all accomplished in the completed implementation by the ACS contractor and, where required, with support from the suppliers of the supporting systems. Specific requirements were established in the ACS specifications that aided in implementation process and where these requirements were not established in the specifications, implementation was more difficult.

The planned integration with the regional Advanced Traveler Information and Trip Planning Systems (4.2.1.2.2) was not implemented, largely due to insufficient infrastructure within these external systems. While the ACS has the capability to provide the required information to these systems, the systems are not yet developed to the extent where they can receive and process the data, and the regional agencies are not yet interested in implementing this capability. This function, therefore, remains an application to be implemented in the future.

5.4.1.1 Technical Issues

There were no specific technical issues encountered in implementing the required data exchanges for the *integration of the fixed route scheduling system and the paratransit scheduling system (4.2.1.1.1 and 4.2.1.1.2)*. The need for these specific integration tasks was clearly identified in the procurement specifications, which established by contract the required coordination and cooperation. The ACS supplier and the scheduling system suppliers developed the required Interface Control Documents (ICD) that established the guidelines for the data exchange.

The integration of the AVL and CAD data and the linking of AVL and schedule data to transit center signs (4.2.1.1.3 and 4.2.1.1.4) were all handled internally within the ACS supplier's system. These features and functions were specifically identified in the procurement specifications and became a part of the ACS system. Consequently, there were no apparent technical issues beyond issues that may have been handled internally by the system supplier; although, the ACS supplier did have to enhance its application to include the on-demand audible announcements.

5.4.1.2 Institutional Issues

The integration of *the fixed route scheduling system and the paratransit scheduling system (4.2.1.1.1 and 4.2.1.1.2)* did present some institutional issues, some of which could be resolved through the specification and contract development and others that, simply, had to be worked-out through the implementation process. Specifically, these issues concern agreements that had to be reached regarding the timing and format of the data to be exchanged between the scheduling systems and the ACS. Each system was a new procurement that had not been completed prior to the start of the ACS implementation. Each was handled differently and, as such, presented different issues.

1) **Fixed Route Scheduling System:** This implementation was near complete at the start of ACS implementation, and the specification and resulting contract required the ACS supplier to be fully responsible for implementation of the required interface. This commitment essentially required the ACS supplier to include the scheduling system supplier as a subcontractor, thus making development of the interface a much smoother process to Intercity Transit. While some issues did arise, instances of “finger pointing” were substantially reduced.

2) **Paratransit Scheduling System:** This implementation was just underway when the ACS implementation was started. Because of the timing of the two projects, the specification and contract did not place the responsibility for development of the interface with the ACS supplier. Consequently, this interface development coordination became an Intercity Transit responsibility. Differences in the manner in which the scheduling system handled manifests and the manner in which the ACS expected them to be handled, details of the specific data to be exchanged, and delays in the implementation of the scheduling system created delays in the final implementation and rollout of these functions.

Integration of *external systems (4.2.1.2.2)* did encounter institutional issues that frequently arise when exchanging data with other agencies, and as such, has delayed implementation of data exchange in support of regional customer information services. Frequently, the “other” system to which data is to be exchanged is not yet in operation or prepared to accept the data, and occasionally, implementation of the information exchange is not a high priority with the “other” agency. Accordingly, work to implement this capability must remain delayed until all parties are in agreement with the need and the method of implementation.

5.4.1.3 Conclusions

While the implementation of advanced transit communications systems frequently require some development and therefore include some degree of risk that goes along with development activities, the procurement documents and resulting contract placed the resolution of technical issues with the ACS supplier. Close monitoring of these activities during implementation ensured that any issues that arose were being suitably handled and, as such, did not affect implementation.

The one exception to this was the institutional issues associated with the paratransit scheduling system interface. The procurement of this scheduling system was progressing in parallel with the ACS, and substantial new development was required by the scheduling system supplier. These items created delays in delivery of the scheduling system, resulting delays to the ACS Dial-A-Lift functionality.

An important lesson to consider when implementing a comprehensive transit communications and management system, like the ACS, is to phase the implementation of the ACS and critical supporting systems such that the supporting systems are complete before implementation of the ACS is started. Additionally, it is best if the ACS implementation contract can place the responsibility for the implementation of required supporting system interfaces with the ACS supplier.

5.4.2 Lessons Learned on the Experiences, Challenges, and Approaches Used in Achieving Consistency with the National ITS Architecture and/or Implementation of ITS Standards

The planned interfaces and conformance to ITS standards met with some degree of success, but there were situations where for a variety of reasons the desired compliance could not be achieved. The specific experiences associated with implementation of interface standards for vehicle equipment alarms, destination signs, and fareboxes are described in the following sections:

5.4.2.1 Vehicle Equipment alarms

Onboard monitoring and reporting vehicle alarms/status to the fixed-site systems for notification to the dispatcher and maintenance supervisor fell into two categories: fixed route buses and Dial-A-Lift (paratransit) vans. An interface conforming to the SAE J1708/1587 standard was specified, which was generally achievable for the fixed route buses. The Intercity Transit requirement to have the PID IDs translated into fault codes did require some additional time to clearly identify and define the specific alarms/statuses to be reported and to complete the required software development, but in the end, most of the required alarms/statuses were adequately reported. For at least one case, the PID reported by one engine manufacturer had a different meaning than the same PID reported by the other engine manufacturer. For one manufacturer, the standard PID definition was used, and for the other manufacturer the PID was used for a different condition. This situation caused some confusion and ultimately requires manual intervention when the condition is reported. Essentially, conformance with the standards is somewhat supplier dependent.

The Dial-A-Lift vans did not have the specified SAE J1708/1587 interface available. The standard diagnostic interface for these Ford vans was OBD II. Even though a third-party conversion device was located to convert OBD II to RS232, monitoring of the required alarms/statuses was determined unachievable at reasonable cost and the requirement was deleted.

5.4.2.2 Destination Signs

ACS interface with the existing destination signs utilized the RS232 interface that was available at the signs. This was a standard capability of the onboard ACS system equipment and it met the requirement for automatic control of the destination signs. The SAE J1708/1587 interface was not available with the existing signs, but the lack of this interface capability did not limit the specified functions.

5.4.2.3 Farebox

The onboard ACS vehicle equipment interface with the farebox utilized the SAE J1708/1587 interface. Even though the recently acquired fareboxes were provided with required interface capability, Intercity Transit did have to add the required internal cable to each farebox to support this interface. For the most part, the required data exchange with the fareboxes was achieved, enabling the farebox to receive the ACS logon and vehicle location data and enabling the ACS to receive alarms from the farebox. However, as with the engine diagnostics, not all of the PIDs defined by the standard were implemented by the farebox manufacturer. Most notably, the farebox did not support the PID enabling the ACS to change the “fare set”.

5.4.2.4 Conclusions

The use of communications standards for the implementation of onboard system interfaces is an important objective that over time should simplify the implementation of these interfaces, require less development, and open the door for interchangeability among devices and subsystems. The reality is that adherence to the standards remains manufacturer-dependent. Some manufacturers had adopted the standards, some have adopted only a portion of the standards, and some have made changes to the standards. In the case of this project, the limitations were not with the ACS supplier, who was prepared to implement the standards as written. The limitations were with the manufacturers of systems with which the ACS was to exchange data. Until market pressures force conformance to the standards, some degree of development and lack of function will continue to occur.