

USE OF ITS TECHNOLOGY FOR MANAGEMENT OF FREIGHT AND TRANSIT ASSETS



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EXECUTIVE SUMMARY

The Michigan Department of Transportation (MDOT) is an intermodal agency tasked with the mobility of the state's citizens, businesses and visitors. Freight and public transit are essential components of Michigan's transportation system. To further MDOT's goal of leveraging technology to maximize safety, mobility, environmental performance, and asset management through mode-specific research programs, MDOT contracted with the Center for Automotive Research (CAR) to conduct a study of potential intelligent transportation system (ITS) technology for the management of freight and transit assets. This report presents the results of CAR's analysis, conclusions, and recommendations.

Freight and transit ITS systems are broad and multifaceted. Many factors will influence the use of ITS technologies and the development of corresponding information systems; these factors include functionality, costs, mode, geographic coverage, and private sector involvement. Any ITS design and deployment in Michigan should be focused on efficient deployment, proven functionality, and interoperability. System design can benefit from MDOT assuming a leadership role in facilitating ITS deployment across functional and geographic borders. MDOT has a broad scope of consideration and responsibility, and is uniquely positioned to promote cross-sector and cross-municipal cooperation.

Successful deployment of ITS technologies for the benefit of the freight industry will depend on interagency cooperation and strong partnerships with industry stakeholders. A multi-sector working group can provide an excellent opportunity to further explore the possibilities of using ITS to assist with the development of statewide or interstate freight programs. Specifically, such a group could:

- Cooperatively analyze the intermodal

freight transportation system in Michigan and identify physical and information exchange bottlenecks

- Explore the solutions to challenges across all modes and identify key technology program areas (e.g., border-crossing operations, freight corridor management, commercial vehicle operations, advanced fleet management, congestion mitigation, managing manufacturing supply chains, etc.)
- Develop pilot freight ITS demonstrations through public private partnerships when new opportunities emerge. Examples include the I-94 Truck Parking Management and Information System, progress associated with the New International Trade Crossing project in Detroit, and the ongoing federal Smart Roadside Program
- Share information, best practices, and lessons learned with the freight community at large

Many transit agencies have already implemented various ITS programs into their operations. Most have the ability to track buses in real-time, and many are using some form of demand-responsive dispatching. State-level guidance and coordination on the deployment of such technologies combined with integrated corridor management could improve service for multiple transit modes. For example, transit agencies using advanced ITS systems could deploy vehicles in real-time response to waiting passengers (or even reservations). Vehicles could move efficiently through cities by communication with infrastructure and receiving signal priority. Interoperable systems could facilitate inter-agency coordination, allowing travelers to seamlessly transfer from the services of one transit agency to another.

To ensure ITS deployments for freight and transit are focused on efficient deployment, proven functionality, and interoperability, guidelines recommended by the ITS Joint

Program Office (JPO) should be followed. The National ITS Architecture has standardized the design of most any conceivable application of ITS technology. The National ITS Architecture and associated standards represent decades of research and best practices, with a focus on broad long-term interoperability. MDOT maintains six regional ITS architectures and deployment plans. All MDOT regional architectures are predicated upon the National ITS Architecture, ensuring

conformance to federal requirements, interoperability and potential for growth and integration. Continued deployment and integration of ITS technologies has great potential for transforming the current tangle of freight and transit schemes into a coherent system. The State of Michigan and MDOT should continue cooperation with private sector, municipal, and federal partners to deploy ITS systems that are strategic, interoperable, and considerate of future developments.

INTRODUCTION

Freight and public transit are essential components of Michigan's transportation system. A primary consideration is that Michigan is home to several of the nation's most significant international freight gateways. The development, adaptation, and deployment of ITS technologies to commercial vehicle platforms will have significant impacts and special implications to the statewide transportation planning process and economic well-being. Furthermore, quality public transit systems facilitate efficient movement of visitors, residents, and workers, a necessity for a healthy local economy. As a result, the Michigan Department of Transportation (MDOT) asked the Center for Automotive Research to investigate the use of ITS technologies for management of freight and transit assets in the State of Michigan.

To explore the potential for employing ITS applications for freight and transit asset management in Michigan, CAR researchers conducted a systematic review of national freight and transit ITS research programs and policies and international and domestic

best practices for transit and freight ITS. The CAR research team also conducted interviews with public transportation service providers and commercial vehicle operators. Because freight and transit ITS technologies are so broad in scope, this effort focused on the implications of national programs, the linkages between various ITS applications and data management, and the regulatory requirements and legal implications of such systems for both the public and private sectors.

The purpose of this report is to further MDOT's goal of leveraging technology to maximize safety, mobility, environmental performance, and asset management through mode-specific research programs focused on freight and transit ITS applications. The report includes a brief description of freight and transit ITS research within the broader national ITS program, discussions of ITS for management for freight and transit assets, regulatory requirements and legal implications, results of stakeholders interviews, conclusions, and recommendations.

U.S. FEDERAL ITS RESEARCH PROGRAMS AND REQUIREMENTS

ITS research and deployment relating to transit and commercial vehicle operations are important components of a broader national ITS program. The ITS Joint Program Office (JPO), located within the Research and Innovative Technology Administration (RITA) of the U.S. Department of Transportation, is responsible for an ongoing ITS program that provides assistance in the nationwide application of ITS as a component of the surface transportation systems of the United States. The ITS JPO currently tracks and organizes various research and development efforts under the ITS Strategic Research Plan 2010-2014 (ITS JPO 2010). Efforts related to the ITS JPO are shown in Figure 1.

REGULATORY REQUIREMENTS FOR TRANSPORTATION PLANNING

The ability of ITS strategies to contribute to statewide transportation goals and objectives is highly dependent on the level of integration with the transportation planning process. The Federal Highway Administration (FHWA) offers guidance to improve such integration. These approaches are reflected in FHWA Register 23 CFR parts 450 and 500 and FTA 49 CFR part 613. Applicable sections include the following, given below:

- 23 CFR 450.104 (Subpart A): Intelligent transportation system (ITS) means electronics, photonics, communications, or information processing used singly or in combination to improve the efficiency or

safety of a surface transportation system.

- 23 CFR 450.208 – 7(f) (Subpart B): The statewide transportation planning process shall (to the maximum extent practicable) be consistent with the development of applicable regional intelligent transportation systems (ITS) architectures, as defined in 23 CFR part 940.
- 23 CFR 450.306 – 8(f) (Subpart C): The metropolitan transportation planning process shall (to the maximum extent practicable) be consistent with the development of applicable regional intelligent transportation systems (ITS) architectures, as defined in 23 CFR part 940.
- FTA 49 CFR 613.200: The regulations in 23 CFR 450, subpart B, shall be followed in complying with the requirements of this subpart. The definitions in 23 CFR 450, subpart A, shall apply.

In addition to the regulatory direction, the following two publications are a sample of the assistance offered at a national level to help guide the integration of planning and ITS, given below:

- Incorporating ITS Into the Transportation Planning Process: An Integrated Planning Framework (ITS, M&O, Infrastructure). NCHRP Project 8-35, Transportation Research Board.
- Applying a Regional ITS Architecture to Support Planning for Operations: A Primer (Publication Number: FHWA-HOP-12-001).

USE OF ITS TECHNOLOGY FOR MANAGEMENT OF FREIGHT AND TRANSIT ASSETS

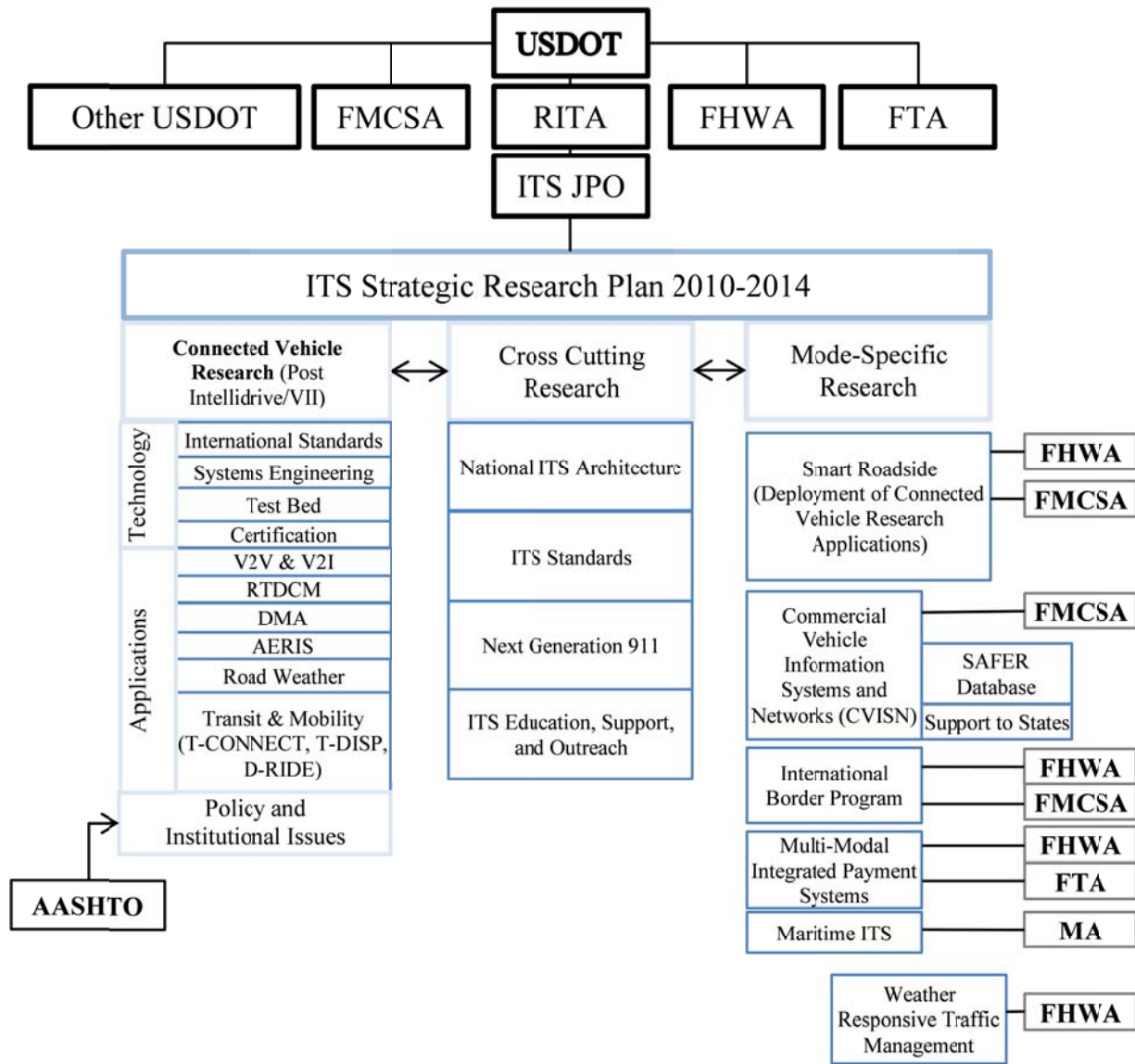


Figure 1. ITS JPO Research Programs
Source: CAR 2012

ITS FOR MANAGEMENT OF MULTIMODAL FREIGHT ASSETS

Freight and commercial vehicle operations are costly activities that involve multiple actors for moving and storing products. These include carriers, shippers, customers, and third party logistics groups. Close collaboration is needed to optimize travel efficiency, load capacity usage, and asset utilization, as well as improve safety. Intermodal freight and the use of advanced communication and information technology are two of the most important trends that have occurred in recent global freight management and fleet operations history. Developing such a system requires significant infrastructure and facility investments, harmonization of operational rules, and standardized information exchange via *intelligent platforms*. For example, various European Union research projects have been developed that cover tracking and tracing, asset management, information technology (IT)-based administrative procedures, integrated door-to-door intermodal system, and web-based multimodal information systems, to improve customer service, increase efficiency, and improve safety (TRKC 2010).

The core of freight ITS consists of obtaining, processing, and distributing information for better use of the transportation system, infrastructure and services. Freight ITS are usually classified into two broad classes: Commercial Vehicle Operations (CVO) for system-wide, regional, national, or continental applications and Advanced Fleet Management Systems (AFMS) dedicated to the operations of a particular firm or group of firms. Usually freight ITS development proceeds along three interconnected directions:

- Vehicular and infrastructure development,
- Electronics and communication hardware, as well as the associated IT software, and
- Methodology – models and algorithms – required to process the data and transform it into meaningful information for advanced

planning, management, and operations.

It is suggested that the ultimate performance and long-term success of freight ITS depends on a balanced integration of these three aspects (Crainic, Gentreau and Potvin 2008). Similarly, some researchers believe that there are three key issues related to the movement of freight: policy, technology (hardware), and intelligence (models, methods, software).

The scope of the United States Department of Transportation (USDOT) ITS research and support program, run through the Research and Innovative Technology Administration (RITA) ITS Joint Program Office (JPO), is broad and multifaceted. This section outlines general applications of freight ITS, applicable federal programs, and examples of regional ITS deployment.

NATIONAL ITS ARCHITECTURE FREIGHT SERVICE PACKAGES

All MDOT regional ITS architectures are predicated upon the National ITS Architecture, ensuring conformance to federal requirements, interoperability and potential for growth and integration. General applications of ITS technology are defined in the National ITS Architecture as *Service Packages*. Service Packages represent a combination of physical components necessary to provide a defined service, such as Electronic Clearance or Weigh-In-Motion services. A service package collects together several different subsystems, equipment packages, terminators, and architecture flows that provide the desired service. The categories listed below are the service packages associated with CVO (Iteris, Inc. 2012).

CARRIER OPERATIONS AND FLEET MANAGEMENT

The Carrier Operations and Fleet Management service package provides the capabili-

ties to efficiently manage a fleet of commercial vehicles. Routes are often constrained by hazardous materials, height, weight, or other restrictions. A route would be electronically sent to the Commercial Vehicle with dispatch instructions. The location of the commercial vehicle can be monitored, and routing changes can be made depending on current road network conditions. Once a route has been assigned, any changes are coordinated between the Fleet and Freight Management subsystem and the Commercial Vehicle. Commercial freight operations, such as United Parcel Service (UPS), utilize such an intelligently generated route assigning system. However, UPS does not integrate live-road conditions into live rerouting at this time. A physical component and connection diagram of this service package is given in Figure 2, below.

FREIGHT ADMINISTRATION

The Freight Administration service package provides cargo security and location tracking. Interconnections are provided to intermodal freight shippers and intermodal freight depots for tracking of cargo from source to destination. Any tampering or security breach is reported to the Fleet and Freight Management subsystem. In addition to exceptions (e.g., alerts) that are reported, on-going indications of the state of the various freight equipment are reported to the Fleet and Freight Management subsystem and Commercial Vehicle Driver. Freight managers may decide to take further action on the alerts and/or provide responses that explain that the alerts are false alarms. If no explanation is received, the Fleet and Freight Management subsystem may notify an Emergency Management sub-

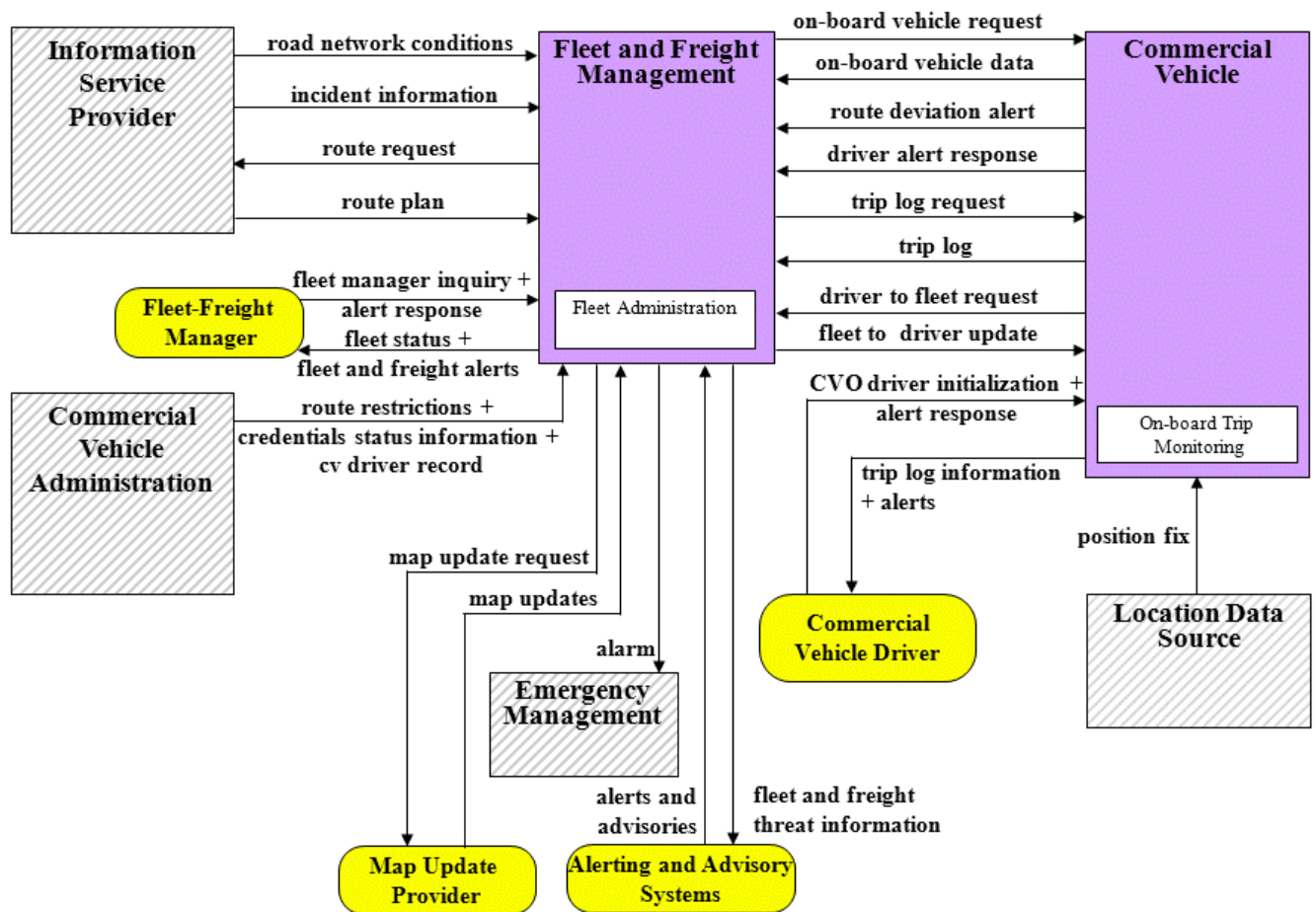


Figure 2. Carrier Operations and Fleet Management Service Package Example

Source: Iteris, Inc. 2012

system. Commercial vehicle and freight security breaches may also be sent to a Commercial Vehicle Check subsystem.

ELECTRONIC CLEARANCE

The Electronic Clearance service package provides for automated clearance at roadside check facilities. The roadside check facility communicates with the Commercial Vehicle Administration subsystem to retrieve infrastructure snapshots of critical carrier, vehicle, and driver data to be used to sort passing vehicles. This allows a cleared driver/vehicle/carrier to pass roadside facilities at highway speeds using transponders and Field-Vehicle Communications to the roadside. Results of roadside clearance activities will be passed on to the Commercial Vehicle Administration. The roadside check facility may be equipped with Automated Vehicle Identification (AVI), weighing sensors, transponder read/write devices and computer workstations.

INTERNATIONAL BORDER ELECTRONIC CLEARANCE

The International Border Electronic Clearance service package provides for automated clearance at international border crossings, including requirements that are not covered by the Electronic Clearance Service Package.

COMMERCIAL VEHICLE ADMINISTRATIVE PROCESSES

The Commercial Vehicle Administrative Processes service package supports program administration and enrollment, and provides for electronic application, processing, fee collection, issuance and distribution of Commercial Vehicle Operations credential, and tax filing. Through this process, carriers, drivers, and vehicles may be enrolled in a variety of programs including electronic clearance and wireless inspection programs which allow commercial vehicles to be screened at mainline speeds. At this time, the nationwide network of electronic inspec-

tion and clearance systems are a patchwork of independent (e.g., state-wide) programs. Upgrading to National ITS Architecture standards will improve program interoperability, and many states are in the process of upgrading. Until all systems have been upgraded to national standards, a Commercial Vehicle Administrative Processes Service Package can help fleet managers navigate the patchwork of electronic clearance.

WEIGH-IN-MOTION (WIM)

The Weigh-In-Motion service package provides for high speed weigh-in-motion with or without AVI capabilities. This service package provides the roadside equipment that could be used as a stand-alone system or to augment the Electronic Clearance service package. Freight companies, such as UPS, utilize electronic weigh-in-motion service packages. However, such systems are often not integrated into a larger fleet management ITS system.

ROADSIDE COMMERCIAL VEHICLE OPERATIONS SAFETY

The Roadside Commercial Vehicle Operations Safety service package provides for automated roadside safety monitoring and reporting. It automates commercial vehicle safety inspections at the roadside check locations. This facilitates safety inspection of vehicles that have been pulled off the highway as a result of the automated screening process provided by an Electronic Clearance service package. In this scenario, only basic identification data and status information is read from the electronic tag on the commercial vehicle. The identification data from the tag enables access to additional safety data maintained in the infrastructure which is used to support the safety inspection, and may also inform the pull-in decision. More advanced implementations may utilize on-board vehicle safety monitoring and reporting capabilities in the commercial vehicle to augment the roadside safety check, as described in the subsequent service package.

ON-BOARD COMMERCIAL VEHICLE OPERATIONS SAFETY

The On-board Commercial Vehicle Operations Safety service package provides for on-board commercial vehicle safety monitoring and reporting. It is an enhancement of the Roadside CVO Safety Service Package and includes support for collecting on-board safety data via transceivers or other means.

COMMERCIAL VEHICLE OPERATIONS FLEET MAINTENANCE

The Commercial Vehicle Operations Fleet Maintenance service package supports maintenance of CVO fleet vehicles with on-board monitoring equipment and Automated Vehicle Location (AVL) capabilities within the Fleet and Freight Management Subsystem. Records of vehicle mileage, repairs, and safety violations are maintained to assure safe vehicles on the highway.

HAZARDOUS MATERIALS (HAZMAT) MANAGEMENT

The Hazardous Materials (HAZMAT) Management service package integrates incident management capabilities with commercial vehicle tracking to assure effective treatment of HAZMAT material and incidents.

ROADSIDE HAZMAT SECURITY DETECTION AND MITIGATION

The Roadside HAZMAT Security Detection and Mitigation service package provides the capability to detect and classify security sensitive HAZMAT on commercial vehicles using roadside sensing and imaging technology. Credentials information can be accessed to verify if the commercial driver, vehicle and carrier are permitted to transport the identified HAZMAT.

COMMERCIAL VEHICLE DRIVER SECURITY AUTHENTICATION

The Commercial Vehicle Driver Security Authentication service package provides the ability for Fleet and Freight Management to detect when an unauthorized commercial

vehicle driver attempts to drive their vehicle based on stored driver identity information.

FREIGHT ASSIGNMENT TRACKING

The Freight Assignment Tracking service package provides for the planning and tracking of the commercial vehicle, the freight equipment, and the commercial vehicle driver. Any unauthorized changes are determined by the Fleet and Freight Management subsystem and then the appropriate people and subsystems are notified.

THE COMMERCIAL VEHICLE INFORMATION SYSTEMS AND NETWORKS (CVISN) PROGRAM

The Commercial Vehicle Information Systems and Networks (CVISN) program was established in the mid-1990s as a means to expedite and coordinate deployment of ITS to promote safety, enhance productivity and efficiency, and reduce operating costs in CVO. A key activity within this track is operational support of the national Safety and Fitness Electronic Records (SAFER) database to enable States' CVISN deployed applications. Use of the CVISN Architecture for planning and deployment enables agencies and the motor carrier industry to integrate systems to share data. Working together in this manner greatly leverages the capability of the individual systems, allowing agencies and firms to accomplish more than they could independently, in a more cost-effective and timely manner. There are two levels of CVISN functionality for States and motor carrier firms:

- Core CVISN functionality provides specific capabilities in three areas:
 - Safety information exchange.
 - Electronic credentialing.
 - Electronic screening.
- Expanded CVISN leverages the functionality of the Core CVISN systems to provide further capabilities for:
 - Driver information sharing.

- Enhanced safety information sharing and data quality.
- Expanded electronic credentialing.

Examples of Expanded CVISN projects include: virtual weigh stations, license plate readers, oversize/overweight permitting, one-stop shops and electronic portals, and driver information sharing. States have used federal and other sources of funding to plan CVISN deployment and implement all or part of the core capabilities associated with safety information exchange, interstate credentials administration and roadside electronic screening functions. Michigan is one of the 46 States that have completed a CVISN Top-Level Design and CVISN Program Plan, and is one of the 22 States that are in the process of deploying core CVISN functionality (FMCSA 2012).

THE SMART ROADSIDE PROGRAM

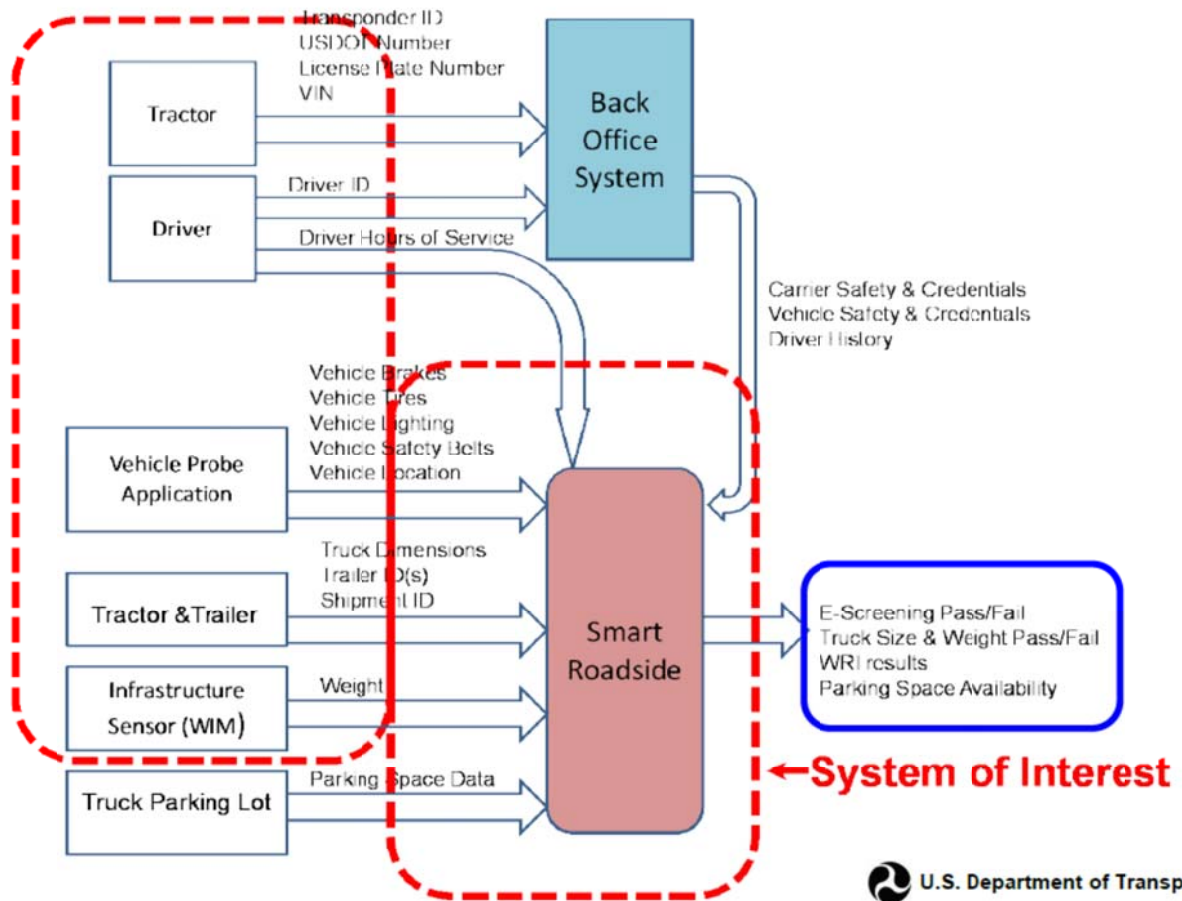
The Smart Roadside Program is a joint modal initiative between the Federal Highway Administration (FHWA) and Federal Motor Carrier Safety Administration (FMCSA) and is intended to be a new component of the broader CVISN Program. The Smart Roadside Program encompasses technology and information-sharing research efforts with commercial vehicle roadside elements that are crucial to the missions of the DOT, in particular relating to the connected vehicle initiative. Smart Roadside is a system envisioned to be deployed at strategic points along commercial vehicle routes to improve the safety, mobility, and efficiency of truck movement and operations on the roadway. It is a concept where private- and public-sector motor carrier systems will continue to operate as intended and where information collected for one purpose can be shared where authorized to serve multiple stakeholders and uses. The objective is to apply advanced technologies to create more efficient and streamlined processes and to share data in real time or near-real time to maximize its utility (RITA 2012).

The Smart Roadside Program has four focus areas (see Figure 3):

- *Wireless Roadside Inspections* - To use technologies that currently exist and to dramatically increase the number of safety inspections.
- *Wireless Roadside Inspection Program* - To increase the number and frequency of safety inspections at the roadside and obtain data about the commercial vehicle and its driver. The program is examining technologies that can transmit safety data directly from the vehicle to the roadside and from a carrier system to a government system.
- *Virtual Weigh Station/Electronic Permitting* - This is an essential way to streamline operations for safety and size and weight and credentialing enforcement. This is a way to determine if the vehicle needs to be inspected and allowing compliant carriers to pass through quickly. It can also identify potentially unsafe carriers using a more streamlined process;
- *Truck Parking Programs* – To provide real-time parking information to truck drivers to help plan their trips.

The Smart Roadside Program is an important component of USDOT Commercial Vehicle ITS Research Plan. It is anticipated that Smart Roadside Deployment Guidelines and Specifications will be developed in the fourth quarter of 2014 (Mueller 2011). However, local applications of these programs could have started early. For example, Michigan Department of Transportation (MDOT) has received a grant to develop the I-94 Truck Parking Management and Information System. This system will include alerts and message signs to drivers indicating parking space vacancies available in the corridor at rest areas and truck stops. The information also will be available online and through industry logistics networks. Once successfully deployed, the system could be initiated on other corridors in Michigan (MDOT August 2012).

USE OF ITS TECHNOLOGY FOR MANAGEMENT OF FREIGHT AND TRANSIT ASSETS



INTERNATIONAL BORDER PROGRAM

The International Border Program focuses on ITS applications that will improve safety and mobility, reduce emissions, and improve security at our Nation's borders. It includes CVO, variable toll pricing, advanced traveler information systems (ATIS), electronic screening, and other technologies. At the U.S./Canada border location the project will center on the implementation of International Border Crossing E-Screening and other commercial vehicle safety management ITS applications (RITA 2012).

MDOT has been actively involved in ITS applications at the U.S.-Canada international border crossings. For example, MDOT is taking a lead role in preparing an implementation plan for expediting traffic flow across the

border at the three bridge crossings and one tunnel between Michigan and Ontario. MDOT is also working closely with USDOT, other federal agencies, and Canada's partners on the Beyond the Border Action Plan. The primary goal of the Beyond the Border Action Plan is to ensure that cargo is inspected only once when entering either Canada or the United States (U.S. White House 2011).

INTERNATIONAL FREIGHT DATA SYSTEM (IFDS)

In 2009, the USDOT formed a partnership to create the International Freight Data System (IFDS), a jointly-shared database that interfaces with the U.S. Customs and Border Protection's (CBP) Automated Commercial Environment (ACE) program. USDOT will use both personally identifiable information (PII)

and non-PII downloaded from ACE via a new Government-wide system called the International Trade Data System (ITDS) to perform a range of agency functions. This will include PII on members of the public who engage in international commerce and hold licenses, registrations and/or other certifications that Federal statutes authorize USDOT to monitor and/or regulate. Privacy management is a critical component of the development of IFDS. Records contained in the IFDS are subject to the Privacy Act. In addition, system security will be certified and accredited in accordance with DOT information technology security standard requirements as part of the design, testing, and deployment of IFDS (RITA 2012).

benefits to public and private sectors. However, in order to be successful, developing an integrated data and information management system would be critical (TRB 2011a). National Cooperative Freight Research Program (NCFRP) Report 9 documented the results of a study to develop specifications for content and structure of a national freight data architecture that serves the needs of public and private decision makers at the national, state, regional, and local levels. The research identified the following categories of components to include in the freight data architecture:

- Physical transportation components,
- Cargo or freight,
- Freight functions or roles,
- Business processes,
- Data sources,
- Freight-related data,
- Freight data models,
- Freight data standards, and

NATIONAL FREIGHT TRANSPORTATION DATA ARCHITECTURE

Widespread deployment of freight ITS applications has the potential to bring a variety of

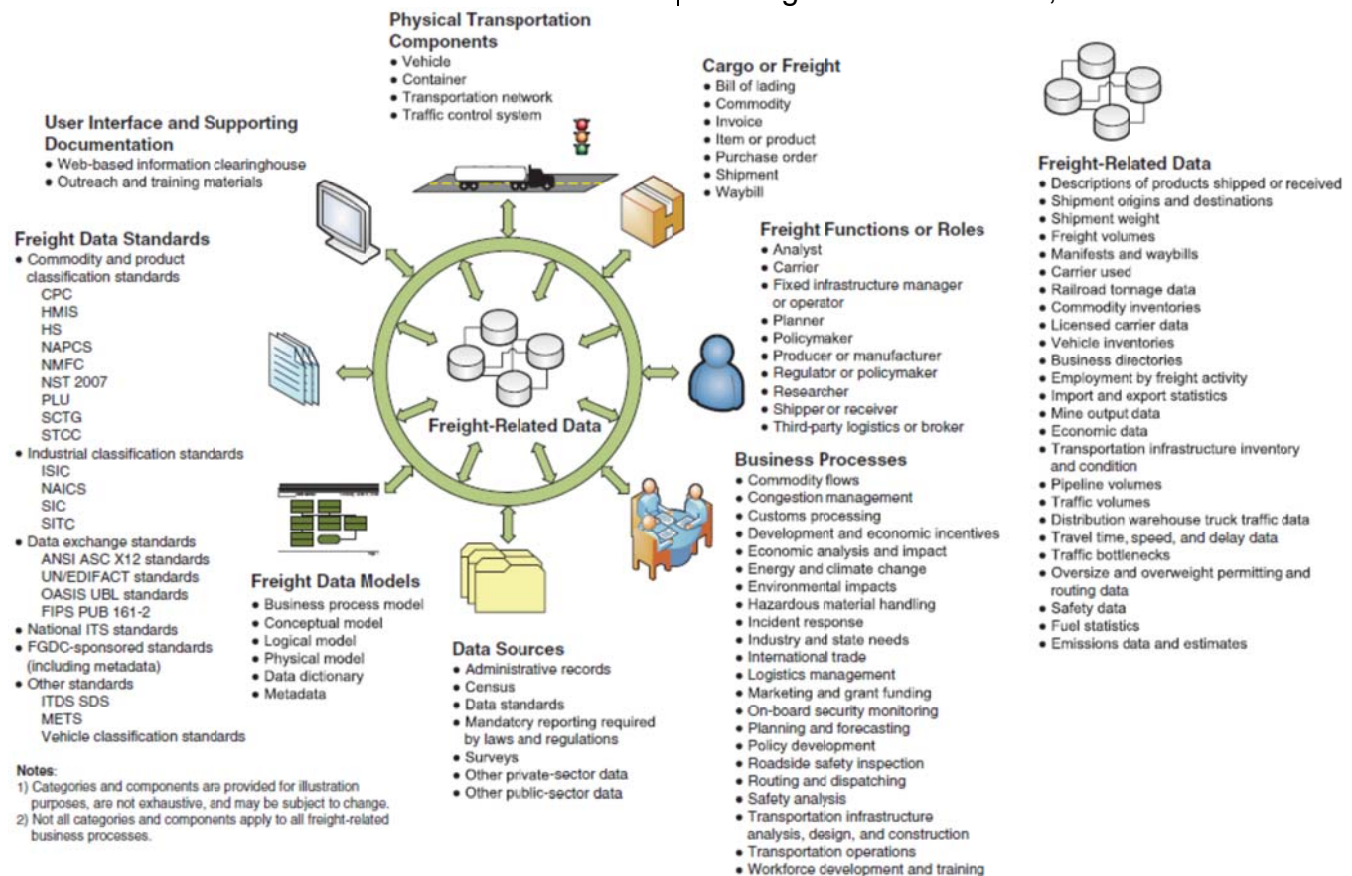


Figure 4. Freight Data Architecture Framework and Components

Source: TRB 2011a

- User interface and supporting documentation.

Figure 4 shows a high-level modular conceptualization and lists different categories of components. Each category and each component can be thought of as an object or dimension that can be defined and characterized using appropriate information parameters such as description, domain, aggregation levels, attributes, and performance measures. The diagram recognizes the scalable nature of the national freight data architecture and enables the production of a variety of diagram versions (as well as tabular representations) depending on what implementation level is pursued. For example, for a single-application data architecture that only focuses on commodity flows, it may not be necessary to depict (at least not in detail) other freight functions and business processes. Similarly, not all data standards would need to be considered, and the requirements for user interfaces to support that data architecture would be relatively minor.

REGIONAL DEPLOYMENT OF FREIGHT ITS

Implementation of freight ITS systems will require close cooperation and coordination among a multitude of public agencies, private firms and other affected stakeholders. The following paragraphs discuss two regional and local examples of integrated freight ITS strategies and applications.

The I-95 Corridor Coalition is an alliance of transportation agencies, toll authorities, and related organizations, including public safety, from the State of Maine to the State of Florida, with affiliate members in Canada. The I-95 Corridor Coalition Commercial Vehicle Infrastructure Integration (CVII) Program is one of the major initiatives in the national connected vehicles development effort. It was initiated in 2009 focusing on developing, testing and deploying 5.9 Gigahertz (GHz) dedicated short range communications (DSRC) technology for heavy-duty vehicles. The I-95 Corridor Coalition CVII Architecture is presented in Figure 5.

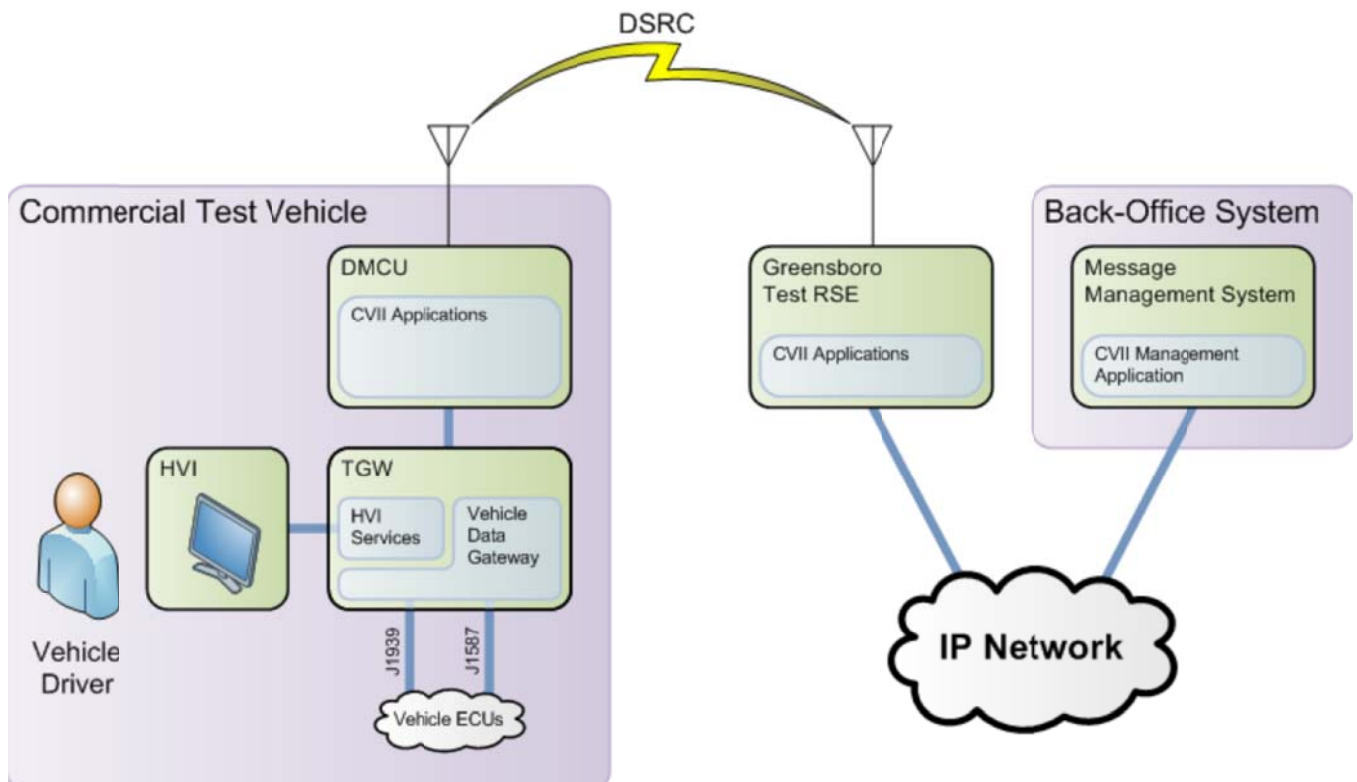


Figure 5. I-95 CVII Architecture
 Source: I-94 Coalition 2008

The CVII activities to be exhibited include safety and mobility applications between vehicles and roadside infrastructure (V2I) and vehicle to vehicle (V2V) communications, including:

- In vehicle signage and traveler information including traveler advisories;
- Vehicle probe data including location, heading, speed and time;
- Commercial vehicle driver credential verification including vehicle enabling/disabling for security purposes;
- Enhanced mainline screening of commercial vehicles for wireless safety inspections including driver credential information and vehicle safety systems' status (brakes, lights, seat belt, and tires);
- Maintenance vehicles broadcasting location and plowing/work zone operations to other vehicles;
- All vehicle driver warnings including blind side, tailgating, emergency braking ahead, and safe to pass/safe to merge; and
- Railroad/highway at-grade crossing driver warnings.

Featured CVII projects include traveler information services projects, coordinated incident management and safety projects, intermodal projects, commercial vehicle operations projects, and electronic payment services projects. When complete, CVII will dramatically enhance commercial vehicle mobility and reduce accidents, fatalities, and injuries through greater situational awareness by driver advisories, driver warnings, and system control of vehicles.

Oregon is one of the few states that currently charge a commercial Vehicle Miles Traveled (VMT) tax. Truck Road Use Electronics (TRUE) is a pilot project that uses smart phone data in order to simplify truck VMT tax collection. The TRUE project tested a smart phone application with a global positioning system (GPS) device and microprocessor that automates the collection of the state's truck VMT tax. The device tracks the miles a truck travels in Oregon and sends the data to

the Oregon Department of Transportation (ODOT) to produce the company's weight-mile tax *invoice* which can be paid online. The automated process is designed to reduce the administrative burden on trucking firms and ODOT while reducing reporting errors and tax avoidance. The TRUE data can also be used to estimate travel times, reliability, and emissions, as well as produce innovative freight performance measures. In addition, there is potential to link TRUE, vehicle registration, and WIM databases for pavement management and freight transportation planning applications (Figliozzi, Kingdon and Wilkitski 2007).

SUMMARY OF FREIGHT RESEARCH PROGRAMS AND IMPLICATIONS

Two featured federal programs relating to freight ITS and commercial vehicle operations are the Commercial Vehicle Information Systems and Networks (CVISN) Program and the Smart Roadside Program, which supports the implementation of the CVISN framework. The Smart Roadside Guidelines are not expected to be finalized until 2014, but their impacts should not be underestimated.

CVISN is a widely adopted program by state DOTs and Customs and Border Control. An integral part in making CVISN work is the use of a transponder. Each transponder has a unique serial number that is assigned to a specific vehicle in the CVISN database. For example, the transponder electronically identifies a truck to a system that automatically checks safety ratings, credentials, and weight while the truck travels at freeway speeds. If all of the checks are satisfactory, the driver will receive electronic notification to bypass the weigh station. Since CVISN is a voluntary program for the carriers, commercial vehicle drivers who drive vehicles with a GVW of 16,000 pounds or greater are increasingly willing to take advantage of the electronic transponder bypass.

The continual pressure on freight, commer-

cial vehicle, and logistics operations to remain efficient and competitive makes freight companies appropriate first-adopters of many ITS technologies. Long-haul trucks have long been equipped with what was perhaps the first generation of connected vehicle technology; the citizens band (CB) radio. Many of today's trucks have now incorporated advanced information and communication devices in both the vehicle and dispatch center to keep freight moving safely and efficiently. While GPS location and cellular communication are independent of public sector infrastructure investment, there are additional ITS applications that may benefit from, or even require, state government participation. For example, the need for efficient freight transportation was a primary driver of the development of electronic weigh-station passes. This first generation Radio-frequency identification (RFID) technology could not have been deployed without extensive multi-level government facilitation. Similarly, automated vehicle identification technology and electronic toll payment usually incorporate elements of a public infrastructure, and travelers of all kinds benefit from such systems.

Facilitating freight transportation in Michigan

is crucial to the state economy. With Port Huron and Detroit, Southeast Michigan is already the busiest international trade gateway in the country. Facilitating freight movement along the NAFTA corridor is the impetus behind MDOT's operations partnership along I-94, including the truck parking management and information system. The Detroit area, however, is underutilized as an economic center for shipping hubs and logistics centers. The primary competition for freight business is with facilities in Columbus, OH and Chicago, IL. The Chicago logistics cluster is much larger than that in Detroit and is in better geographical position to ship to many key metropolitan areas. Attracting new freight and logistics business to the Detroit region must involve providing potential businesses with a specific value proposition that locating near Detroit would be preferential to Chicago. One action that can be taken to promote such economic activity is to provide an infrastructure that would facilitate smooth multimodal freight transportation using proven ITS standards and practices. The upcoming New International Trade Crossing project may represent a great opportunity to embed the latest ITS technology with state of the art techniques and design.

ITS FOR MANAGEMENT OF TRANSIT ASSETS

Similar to freight ITS applications, transit ITS also experienced a rapid pace of improvements in technology in recent years. For example, the proliferation of personal mobile devices has provided new opportunities for information dissemination by public transportation agencies. Another example is the use of radio frequency identification (RFID) technology for tolling by an increasing number of major metropolitan transit systems aiming at greater security, durability and ease of operation for passengers. This section outlines general applications of transit ITS, multimodal integrated payment systems, and transit ITS data management.

NATIONAL ITS ARCHITECTURE TRANSIT APPLICATIONS (SERVICE PACKAGES)

General applications of transit ITS technology are defined in the National ITS Architecture as *Service Packages*. Service Packages represent a combination of physical components necessary to provide a defined service, such as transit vehicle tracking or information services. A service package collects together several different subsystems, equipment

packages, terminators, and architecture flows that provide the desired service. The categories listed below are the service packages associated with public transportation (Iteris, Inc. 2012).

TRANSIT VEHICLE TRACKING

The Transit Vehicle Tracking service package, represented in Figure 6, monitors current transit vehicle location using an automated vehicle location (AVL) System. The location data may be used to determine real time schedule adherence and update the transit system's schedule in real-time. Vehicle position may be determined either by the vehicle (e.g., through GPS) and relayed to the infrastructure or may be determined directly by the communications infrastructure. A Transit Management Subsystem may process this information to update the transit schedule and make real-time schedule information available to the public or another entity via an Information Service Provider (ISP).

Transit vehicle tracking is a common application of ITS for public transit services and is

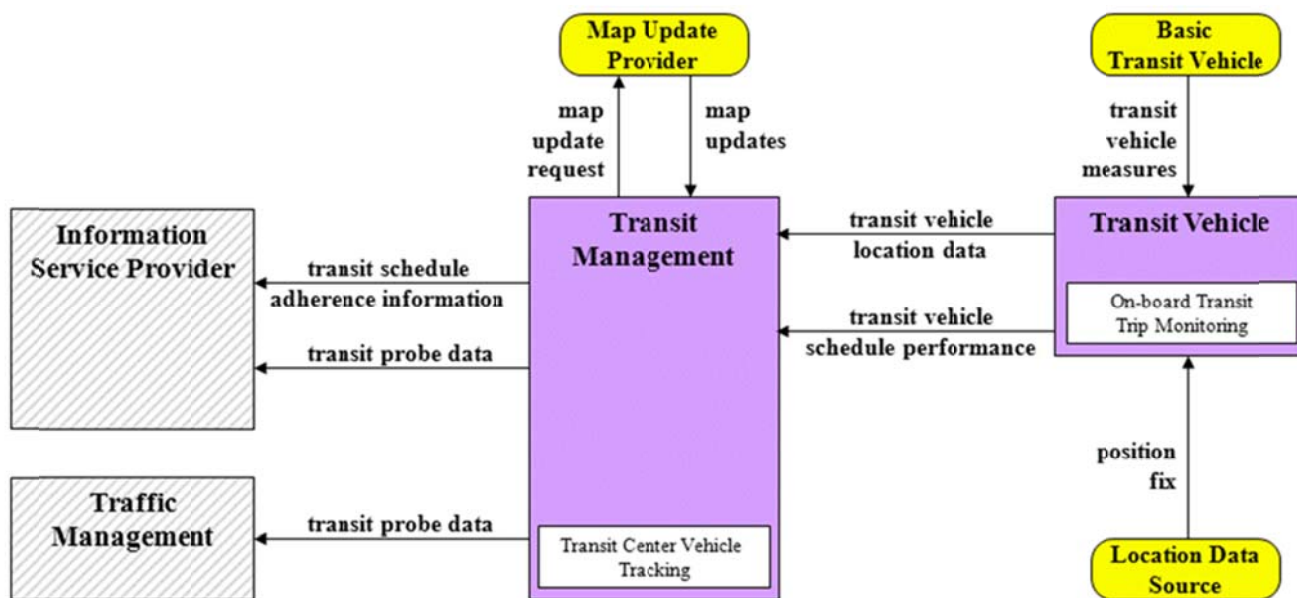


Figure 6. Transit Vehicle Tracking Service Package Graphic Example

Source: Iteris, Inc. 2012

currently being used by transportation agencies in Michigan, such as the Ann Arbor Transportation Authority (AATA). AATA uses vehicle tracking as a component of a commercially available decision support system, *TransitMaster* by *Trapeze ITS* (Miller 2012).

TRANSIT FIXED-ROUTE OPERATIONS

The Transit Fixed-Route Operations service package performs automated dispatch and system monitoring for fixed-route and flexible-route transit services. This service performs scheduling activities including the creation of schedules, blocks and runs, as well as operator assignment. This service determines the transit vehicle trip performance against the schedule using AVL data and provides information displays at the Transit Management Center (TMC). Static and real time transit data is exchanged with ISP where it is integrated with that from other transportation modes (e.g. rail, ferry, and air) to provide the public with integrated and personalized dynamic schedules. This process is represented in Figure 7.

DEMAND RESPONSE TRANSIT OPERATIONS

The Demand Response Transit Operations service package performs automated dispatch and system monitoring for demand re-

sponse transit services. This service performs scheduling activities as well as operator assignment. In addition, this service package performs similar functions to support dynamic features of flexible-route transit services. This service includes the capability for a traveler request for personalized transit services to be made through the ISP Subsystem.

TRANSIT FARE COLLECTION MANAGEMENT

The Transit Fare Collection Management service package manages transit fare collection on-board transit vehicles and at transit stops. It allows transit users to use a traveler card or other electronic payment device. Card-readers, located either in the infrastructure or on-board the transit vehicles, enable electronic fare payment. Data is processed, stored, and displayed on the transit vehicle and communicated as needed to the Transit Management Subsystem.

TRANSIT SECURITY

The Transit Security service package provides for the physical security of transit passengers and vehicle operators. The surveillance equipment may include video, audio systems and/or event recorder systems. Public areas (e.g., transit stops, park and

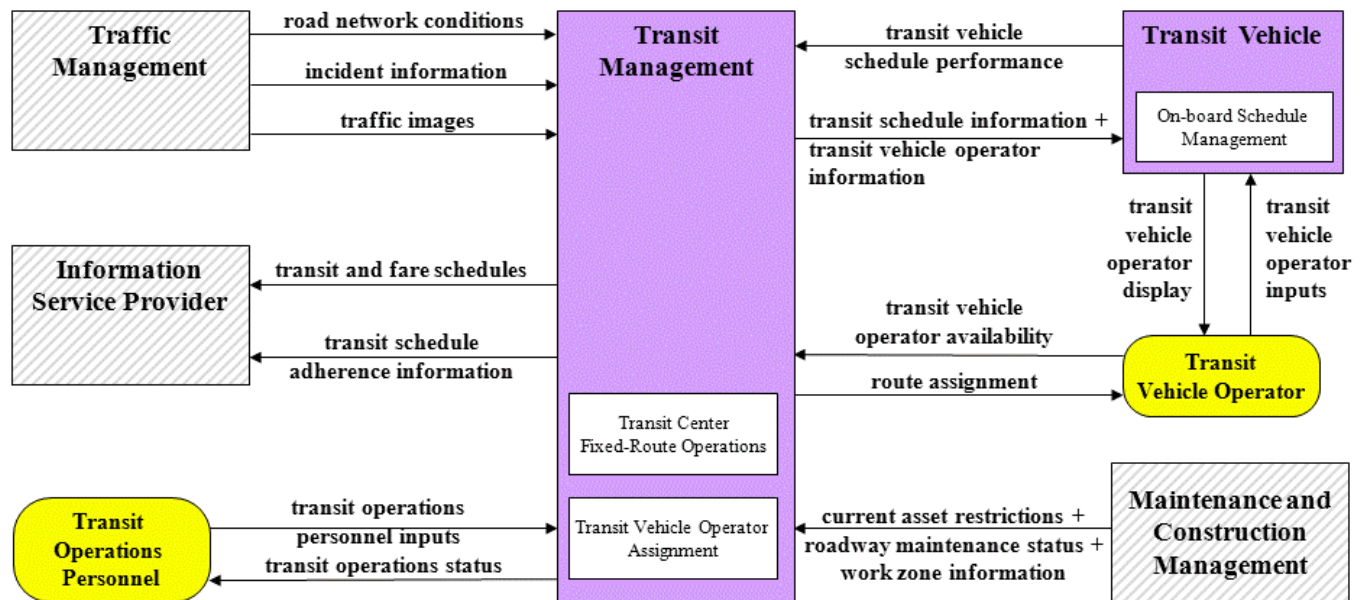


Figure 7. Transit Fixed Route Operations Service Package Graphic Example

Source: Iteris, Inc. 2012

ride lots, stations) may also be monitored with similar surveillance and sensor equipment and provided with transit user activated alarms.

TRANSIT FLEET MANAGEMENT

The Transit Fleet Management service package supports automatic transit maintenance scheduling and monitoring. On-board condition sensors monitor system status and transmit critical status information to the Transit Management Subsystem. Hardware and software in the Transit Management Subsystem processes this data and schedules preventative and corrective maintenance. The service package also supports the day to day management of the transit fleet inventory, including the assignment of specific transit vehicles to blocks.

MULTI-MODAL COORDINATION

The Multi-modal Coordination service package establishes two way communications between multiple transit and traffic agencies to improve service coordination. Multimodal coordination between transit agencies can increase traveler convenience at transit transfer points and clusters (a collection of stops, stations, or terminals where transfers can be made conveniently) and also improve operating efficiency.

TRANSIT TRAVELER INFORMATION

The Transit Traveler Information service package provides transit users at transit stops and on-board transit vehicles with ready access to transit information. The information services include transit stop announcement, imminent arrival signs, and real-time transit schedule displays that are of general interest to transit users. Systems that provide custom transit trip itineraries and other tailored transit information services are also represented by this service package.

TRANSIT SIGNAL PRIORITY

The Transit Signal Priority service package determines the need for transit priority on

routes and at certain intersections and requests transit vehicle priority at these locations. The signal priority may result from limited local coordination between the transit vehicle and the individual intersection for signal priority or may result from coordination between transit management and traffic management centers. Coordination between traffic and transit management is intended to improve on-time performance of the transit system. The AATA is currently working with the City of Ann Arbor, Washtenaw County, and MDOT, to implement a signal priority system on the Washtenaw Avenue corridor. Implementation is being headed by *Trapeze ITS*, who already consults with AATA for ITS services (Miller 2012).

TRANSIT PASSENGER COUNTING

Using sensors mounted on the vehicle, the Transit Passenger Counting service package counts the number of passengers entering and exiting a transit vehicle and communicates the collected passenger data back to the management center. The collected data can be used to calculate reliable ridership figures and measure passenger load information at particular stops.

MULTIMODAL CONNECTION PROTECTION

The Multimodal Connection Protection service package supports the coordination of multimodal services to optimize the travel time of travelers as they move from mode to mode (or to different routes within a single mode). A near-term function supported by this service package would be for a single transit agency to coordinate crossing routes so that passengers on one route would have the opportunity to transfer with minimum wait time to another route within the same transit system. The next level of complexity of this service package would be for this coordination to occur across transit agencies, or between transit agencies and other modes of transportation.

MULTI MODAL INTEGRATED PAYMENT SYSTEMS (MMIPS)

Transit agencies and private sector contractors have made significant progress in deploying electronic payment technologies for tolling systems. The nationwide system is a patchwork of multiple architectures and payment schemes. New research will begin with a needs and feasibility assessment of integrated systems, including analysis of new and emerging technologies and models for operations, financial transactions, and consumer electronics capabilities. This first phase will assess various electronic payment techniques and technologies, such as smart cards, bank-owned cards, cell phones, personal digital devices (e.g., BlackBerry and iPod), and transponders. Further research will be conducted to determine the ITS standards needed to create an open architecture environment. Finally, research will be conducted to identify benefits and costs.

If it is determined that an integrated, multi-modal system is technologically feasible, non-technical research will address institutional issues and customer acceptance, assess market opportunities, analyze back-office clearinghouse operations, and develop one or more business models for consideration in developing policy options. The research is expected to result in the demonstration and evaluation of an integrated system comprised of transit bus service, parking, and tolls (RITA 2012).

TRANSIT ITS DATA MANAGEMENT

The primary purposes of implementing ITS technologies are improving transit operations, enhancing convenience, and facilitating the flow of information to customers. During the process, transit ITS could also generate vast amounts of data related to transit agencies and users. Effective ITS data management depends on the development and maintenance of a diverse supporting infrastructure. Key elements of this infrastructure include an information system for archiving

ITS data, enterprise-level applications (including enterprise Geographic Information System), processes for screening and validating ITS data to ensure its integrity, software tools that support reporting and analysis; data standards, coordination between stakeholders, and human resources with the skills to maintain the infrastructure.

TRANSIT ITS DATA INVENTORY

Some researchers classify transit ITS data into two major categories. The first includes systems that are installed on vehicles, including AVL, automatic vehicle monitoring (AVM), and control heads, automatic passenger counter (APC), magnetic and smart card readers, and electronic registering fare boxes. The second category includes systems supporting customer service, including ticket vending machines, automated phone systems, traffic counting, and the Web (TRB 2008). Data elements recovered from on-board systems and from other systems are presented in Tables 1 and 2, respectively.

ITS DATA STORAGE

ITS data collection has the potential to accrue significant amounts of data that must be stored. However, data storage requirements and costs have decreased to the extent that the amount of data, per se, is not an issue to ITS managers of small transit agencies. For example, ITS data collected by the AATA is simply stored internally on the system server. AATA has never needed to archive information to clear storage space on the server. AATA reported that the amount of data on its current ITS server was approximately 33 Gigabytes (GB) after about ten weeks in service. However, the bulk of this data was legacy data, back to 2008, that had been transferred on to the new server when the hardware was updated by the commercial service provider (*Trapeze ITS*). Additionally, old servers are warehoused on site and can be accessed if legacy information is requested. There is no program in place to archive, back up, or maintain legacy ITS data. However,

USE OF ITS TECHNOLOGY FOR MANAGEMENT OF FREIGHT AND TRANSIT ASSETS

AATA has never had a need to access legacy data.

For large transit agencies with extensive data

collection and archival needs, more robust storage architectures may need to be adopted. The current MDOT position is to save all data in perpetuity and allow for data analytics

across all data. Accommodating potential queries while protecting data from loss or corruption may require advanced data indexing architectures on redundant data warehousing servers. If deemed necessary, data could be further backed-up using a commercial cloud-storage service. Cloud-storage costs are currently approximately \$1.20 per GB per year (<https://developers.google.com/storage/docs/pricingandterms>).

Depending on storage used, the volume of data stored, the length of time it will be stored, and the intended use of the data, costs may vary significantly. The AATA example is a very low end solution. Depending on each agency's needs and plans, costs may vary widely from this example.

TRANSIT ITS DATA SHARING

Transit agencies may share or distribute ITS data for a variety of reasons. Sharing ITS data can benefit the transit agency and general public through resource sharing and collaboration. A variety of stakeholders may request ITS data. For example, academic institutions, transportation planners, and systems analysts may have an interest in the data for research and analysis. The results of such analysis may help transit agencies in improving services.

LEGAL RIGHTS TO USE AND DISSEMINATION OF REAL-TIME ITS DATA

According to Thomas (2011), once real-time ITS data is collected, transit agencies have a limited right to restrict access to the data. Specific aspects of a database may be copy-rightable. However, raw data ("facts") are not

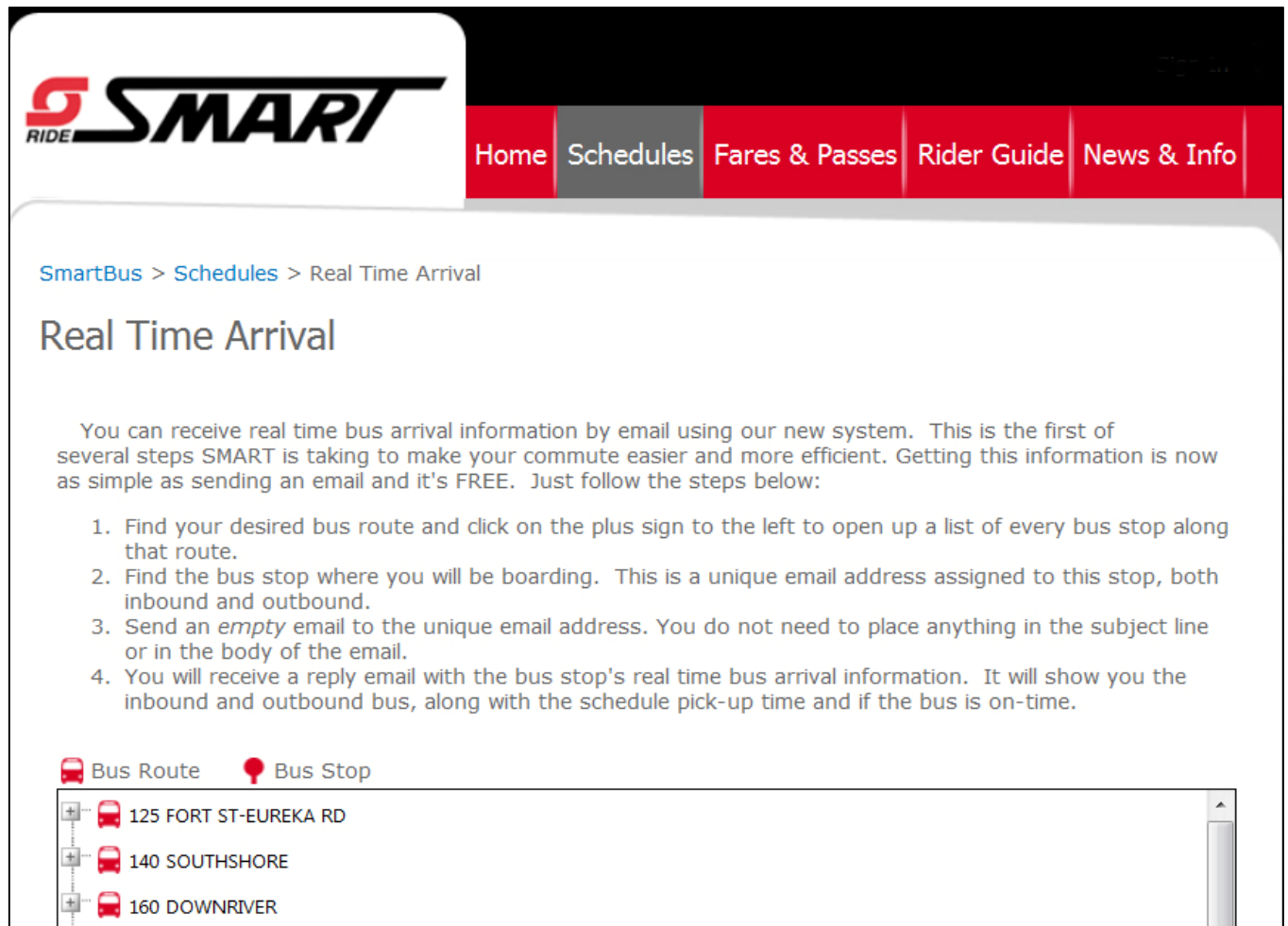


Figure 8. SMART Real Time Arrival Web Page
Source: smartbus.org 2012

copyrightable. A transit agency may retain proprietary rights to the data so long as the data have not entered public domain. But any public agency data may be subject to Freedom of Information Act (FOIA) requests if the data would not compromise public safety or security. Much of this is a moot point, however, as a nationwide survey of transportation agencies found no example of an agency attempting to restrict real-time ITS data from the public. Although many agencies did not share such information, it was primarily due to technical issues or lack of interest (Thomas 2011).

PRIVACY

While there are no standards, *per se*, regarding privacy, this is an important consideration. *ASTM E2259, The Standard Guide for Archiving and Retrieving ITS-Generated Data*, recommends that Privacy Principles developed by *ITS America* be followed. *ITS America* notes that, "privacy law is a patchwork of federal and state statutes, as well as federal and state judicial opinions. The 'right' to privacy as a matter of law in the context of transportation on public roads and other facilities is limited. Intelligent Transportation Systems should provide, at a minimum, privacy protections in conformity with the law of respective jurisdictions" (ASTM International 2003 (2011)). The *ITS America* principles generally reflect a duty of ITS collection agencies to minimize collection and aggregation of personally identifiable information (PII). PII data should be collected only when necessary; allowing anonymous participation in ITS systems may be preferable in many cases. When individualized data is collected, the individual should be aware of the procedure and have a choice of opting out.

ITS DATA PUBLIC AVAILABILITY

ITS data that does not contain individual or sensitive information may be shared with the public. For example, *GoTriangle*, a partnership of public transportation agencies and organizations funded to promote commuter

benefits in the Triangle region of North Carolina, makes bus system data available as GTFS (General Transit Feed Specification) files (GoTriangle 2012). These files allow stakeholders to record and analyze data as it becomes available, or develop smart phone applications that utilize real time transit data. Such activities can assist the transit agency with improving services. The AATA is in the process of setting up a similar process (Miller 2012).

Disseminating useful information to the public in a convenient and helpful way is not always easy, even when the data is available. Many transit agencies do not have the in-house expertise to develop web or mobile applications that are helpful to transit customers. For example, the Detroit-Metro area Suburban Mobility Authority for Regional Transportation (SMART) bus system has recently implemented live tracking of its bus fleet. However, SMART's current method of providing real-time information to riders is inconvenient compared to similar systems. The SMART Real Time Arrival communication scheme is shown in Figure 8 on the previous page.

ITS DATA INSTITUTIONAL AVAILABILITY

In some cases, ITS data that would not be appropriate for public availability may be shared between institutions. For example, the AATA shares data with the University of Michigan (UM). This is a component of a partnership between AATA and UM, whereby UM ID cardholders can obtain free passage on AATA buses. AATA has the capability of tracking ridership associated with a particular ID card, but does not have the information that can relate that card to an individual rider; however, AATA turns this data over to UM, who does have the capability of relating ridership data to individuals. UM can use such data to evaluate the performance of the program. It could be determined, for example, what percentage of staff or graduate students utilize the program.

TRANSIT ITS DEPLOYMENT COSTS

There is too much variation in potential ITS deployment scenarios to generalize cost estimates for even simple systems. However, the USDOT RITA maintains an ITS project cost database as a national resource for transportation professionals to obtain cost estimates for ITS deployments (<http://www.itscosts.its.dot.gov/>). Investment in ITS should be framed as a public service and compared to potential benefits and alternative approaches.

SUMMARY OF TRANSIT ITS RESEARCH PROGRAMS AND IMPLICATIONS

An efficient public transit system generates benefits beyond convenience to users. A good public transit system frees up roadway capacity, decreases energy use and pollution, and stimulates the economy by providing dependable transportation to low-income workers without access to an automobile. Cities and regions with exemplary public transportation systems (e.g., Washington D.C., Chicago, and San Francisco) generally have an advantage of scale and density that Michigan does not share. These cities can attract users from across market segments by being the best transportation option. The density of such areas allows transit agencies to operate even fixed rail services at frequent intervals. Such services are seen by many residents as a convenient low-cost option of commuting or traveling locally.

By contrast, it is often difficult for Michigan transit companies to offer a value proposition of their services that would appeal to average middle-class commuters or travelers with access to a vehicle. No transit agencies currently offer services that can bypass traffic congestion, and the necessity of bus stops makes this option slower. Wait times between busses can often be inconveniently long, and busses that do run are often empty. Alternately, on what is likely the busiest transit corridor in the state (Woodward Ave-

nue), busses are dangerously overcrowded during peak hours.

It is not expected that any significant area of Michigan will see rapid growth or densification that invites natural development of a vibrant public transportation system. Public transit agencies will not likely be able to depend on changing density patterns to change the economics of public transit. However, ITS strategies are evolving that could change the economics of public transit, making it a viable alternative across metropolitan regions and market segments.

Transit agencies already have the ability to track busses in real-time, and many are using some form of demand-responsive dispatching. The evolution of such technologies could lead to intelligent public transit systems that respond to waiting passengers (or even reservations). Vehicles could move efficiently through cities by communication with infrastructure and receiving signal priority. Interoperable systems could communicate between agencies, allowing travelers to seamlessly transfer from the services of one transit agency to another. It is possible that in some locations, using public transit could be a comparative convenience.

Such an intelligent and comprehensive public transit system does not exist in any region in the world. But the technology exists, and the architecture has already been conceptualized. Furthermore, many areas of Michigan that have lost population over recent years have transportation infrastructure with excess capacity. While this is a problem from a maintenance and planning standpoint, it may make Michigan a uniquely suitable area to explore and experiment with new concepts of transportation, including next generation intelligent public transportation systems. Such projects will take a coalition of stakeholders. But the State of Michigan and MDOT are perhaps best positioned to be the hub of information planning for such projects.

RESULTS OF STAKEHOLDER INTERVIEWS

The CAR research team conducted interviews with commercial vehicle operators and public transportation service providers in Michigan. The purpose of the interviews was to understand freight and transit ITS applications at the agency level. The interview questions were as follows:

- What are the major intelligent transportation systems (ITS) applications in your agency?
- What are the primary data you collect from these applications?
- Does your agency collect real-time data about commodity, vehicle location, status of vehicles, and its drivers?
- How do you manage and archive freight ITS data?
- What is your strategy to secure and protect the data?
- What are the major problems associated with ITS data collection and management?
- Do any of the ITS applications integrate with other transportation systems deployed in your service area (e.g., parking information, signal priority, traffic probe, etc.)?
- Do you disseminate real-time information (e.g., for vehicle, such as bus location)? If so, how is it disseminated (e.g., through mobile devices)?
- How do you maintain communications with stakeholders about vehicle and commodity tracking?
- What are your recommendations for improving freight ITS and telematics applications?

Summary findings of stakeholder interviews are presented below. Results of public transportation service provider interviews were supplemented with findings of a 2010 RITA ITS survey.

UNITED PARCEL SERVICE (UPS)

UPS freight vehicles use an "in vehicle information system" that records driver and

vehicle functions (e.g., revolution per minute, braking, etc.). The system also records a driver's time card and the results are used to comply with USDOT driver reporting requirements. Information is not generally transmitted in real time. Instead, it is logged on the vehicle and uploaded when the vehicle is docked at the distribution center. Archival of this data is done at redundant nationwide sites. Data is held in secure servers, is password protected, and is accessible only to necessary employees. Though, typically data is not transmitted in real-time, the system does have an instant alert function for communication with the dispatch center.

UPS uses a separate system for vehicle location tracking of both freight and delivery vehicles. GPS location is relayed every 15 minutes via a commercial cellular network (multiple carriers depending on location). Routes are assigned prior to trucks leaving the distribution center. The distribution center occasionally initiates real-time re-routing, but this is not in response to live traffic or other ITS data.

UPS is also enrolled in various electronic tolling and weigh-in-motion systems, but these are not integrated into the primary system. It may be useful to integrate these systems, but it is not a priority for UPS.

From the perspective of IT management, there is no major difference in operations between differing states or regions. UPS does not envision much that a single state could do to assist in ITS deployment, primarily because UPS is a nationwide company and all operations must be applicable nationwide (Murray 2012).

CON-WAY TRUCKLOAD

Con-way uses several *Qualcomm* products for its freight management and operational purposes, including *Qualcomm* Onboard

Communication System for real time tracking and bidirectional communication between operations department and drivers, *Qualcomm Navigo System* for turn by turn navigation, and *Qualcomm Sensortracs System* for real time engine information (Revolution per Minute, Hard Brakes, Idling, etc.). Real-time data also includes information about commodity, vehicle location, status of vehicles, and drivers. About 60 percent of Con-way's transactions are done through an Electronic Data Interchange (EDI). The EDI integration provides real time location and service status information to Con-way's customers. Currently Con-way's freight ITS applications are not integrated with other transportation systems deployed in the service area (e.g., parking information, signal priority, traffic probe, etc.).

Con-way freight ITS data is integrated with internal IT systems, which run on the IBM I Series. There is a backup I Series that mirrors Con-way's production system as a measure to secure and protect the data. A continual challenge is to integrate all the data collected from freight telematics and ITS into business intelligence tools.

From Con-way's perspective, it is suggested that On-Board Computers (OBCS) manufacturers should focus more on open-source integration with back-end systems. Con-way is expecting that the OBCS industry will move to more of a platform-provider business model; this would allow customers to choose any mobile device without having to lock themselves up to a specific platform (Tewari 2012).

DETROIT DEPARTMENT OF
TRANSPORTATION (DDOT)

In 2010, The DDOT reported that all 450 fixed-route buses used in service were equipped with automated vehicle location (AVL), real-time monitoring of vehicle components, electronic fare payment, and mobile data terminals. Additionally, 350 of these vehicles had automatic passenger counters.

DDOT reported that dynamic real-time information was reported at the central depot and three major bus stops. Real-time information was not available online, but the department does provide a Web-based trip planner (DDOT 2010).

SUBURBAN MOBILITY AUTHORITY FOR
REGIONAL TRANSPORTATION (SMART)

In 2010, SMART reported that all 270 of its fixed-route bus fleet and 109 paratransit vehicles were equipped with AVL, real-time monitoring of vehicle components, automated dispatching, mobile data terminals, and automatic passenger counters. Fixed-route buses are equipped with electronic fare payment by a closed-loop proprietary system. SMART coordinates with selected agencies for automated reservations of paratransit services. SMART reported use of Society of Automotive Engineers (SAE) *J1708* standard for serial data communications (SMART 2010).

In a 2012 interview by CAR, SMART reported that it was in the process of implementing a new Computer-Aided Dispatch (CAD)/AVL system by *ACS, Inc.* Under the existing system, GPS location, on-time performance, passenger count, and vehicle performance are collected and streamed in near real-time. SMART reported that this data was stored on the server without any special archiving process. However, the new system may be collecting more information and they may have to implement an archival process, i.e., backing up data to a disk external hard drive.

SMART reported major benefits to implementation of communications technology including computer aided dispatch and scheduling. SMART reported moderate benefits to use of automatic vehicle location and Geographic Information Systems (GIS) data management, and a lesser benefit from electronic fare payment (SMART 2010). SMART uses a 900 MHz radio network with three towers, and does not report plans to upgrade. There are occasional dead-zones in

this network caused by buildings, topography, etc. SMART currently provides near-real-time information to users. However, the current system is a very basic email-query system. (See Figure 10) SMART is in the process of upgrading to an advanced online system that is scheduled to deploy October 1, 2013.

SMART reported in a survey (SMART 2010) that a cost-benefit analysis of implementing traffic-signal prioritization found that it was not worth pursuing. However, they cite institutional barriers (inter-municipal cooperation) as a primary cost. SMART also reported that it had attempted several times to add interoperable capability with the Michigan State Police. Such a capability could allow buses, for example, to live-route around accident sites or automatically report incidents. However the State Police were not responsive to such a program. SMART reported that it coordinates transit operations with DDOT on major arterial corridors; the details of this coordination were not provided (SMART 2010). The 2012 interview clarified that SMART ITS systems were in no way integrated with DDOT or any other transportation agency. SMART indicated that signal prioritization in corridors may be helpful, as well as connected vehicle technology (i.e., Ann Arbor V2X Safety Pilot Project). However, SMART indicated that the most obvious way to improve service is to improve the fare collection process. SMART utilizes electronic fare collection, but it is not mandatory, so riders can still use cash. Collecting a cash fare is a time consuming process and security issue, and fare-boxes often need maintenance (Evans 2012).

ANN ARBOR TRANSPORTATION
AUTHORITY (AATA)

In 2010, AATA reported that all 72 of its fixed-route bus fleet vehicles were equipped with automated vehicle location (AVL), real-time monitoring of vehicle components, automated dispatching, mobile data terminals,

and automatic passenger counters. In 2012, an interview with AATA clarified that GPS capability is installed on about 70% of the fleet. It is unclear if the rest of the fleet has an alternative AVL system. AATA uses a commercial product by *Trapeze ITS* called *Transit Master*. Every 30 seconds, information is relayed to the ITS server, including: location, "canned messages" from drivers (pre-programmed message set regarding vehicle operations such as taking on a bike, altercations with a passenger, etc.), engine performance codes, bus arrival and departure times, boarding data. All information is stored on the ITS server. There is no official archival process. Digital storage space has not been an issue. Archived information is not shared with the public, but no one has ever requested it.

Buses are also capable of electronic payment via a closed loop proprietary system. This is not integrated into *Transit Master*. The electronic fare boxes are integrated with the University of Michigan electronic ID cards. AATA reported using a *Contactless Fare Media System Standard* (CFMS) for fare collection.

Transit Master has potential capabilities that AATA does not utilize because in-house expertise on the system is lacking. For example, even though the system collects engine performance information, this is not used in maintenance operations. In 2010, AATA reported finding major benefits in use of AVL, communications, GIS data management, computer aided dispatch and scheduling, electronic fare payment, and security cameras. They also reported some benefit of using traveler information systems and automated passenger counters.

AATA has just been upgraded to the latest version of the *Trapeze ITS Transit Master* system including hardware and software. *Trapeze ITS* performed the transition and it was done with no issues. AATA remains in possession of legacy servers, and legacy data is stored on these servers. A limited

amount of legacy data has also been transferred to the existing server. Server access is limited to necessary AATA employees and is password protected.

AATA maintains a *RideTrack* web site for near-real-time information dissemination to users. AATA is in the process of working with *Trapeze* ITS to develop a more advanced real-time tracking site. The plan is to make it open-source to allow for development of outside party applications such as smart-phone

tracking apps (Miller 2012).

AATA is currently working with the City of Ann Arbor, Washtenaw County, and MDOT to implement signal prioritization on the Washtenaw Avenue Corridor. AATA had attempted to engage in such a project in the past, but it was unable to coordinate stakeholder involvement. In the current project, AATA was approached by the municipalities. AATA reports using the *SAE J1708* and *J2395* standards (AATA 2010).

CONCLUSIONS AND RECOMMENDATIONS

The extent of ITS deployment will likely continue to expand for the foreseeable future. The USDOT has put considerable effort into standardizing and streamlining ITS design and deployment through the ITS JPO. The ITS JPO has extensive outreach efforts to assist the public sector in ITS deployment, and even provides free software that can be used to design system architecture.

MDOT maintains six regional ITS architectures and deployment plans. All MDOT regional architectures are predicated upon the National ITS Architecture, ensuring conformance to federal requirements, interoperability and potential for growth and integration. To ensure regional ITS projects for freight and transit are focused on efficient deployment, proven functionality, and interoperability, guidelines recommended by the ITS JPO should continue to be used. The National ITS Architecture and associated standards represent decades of research and best practices.

Successful deployment of ITS technologies for the benefit of the freight industry will depend on interagency cooperation and strong partnerships with industry stakeholders. A multi-sector working group can provide an excellent opportunity to further explore the possibilities of using ITS to assist with the development of statewide or multi states freight programs (similar to the I-95 Corridor Coalition and the ongoing I-94 Corridor efforts). MDOT can leverage existing partnerships from past efforts, such as the I-94 Truck Parking Management and Information System, and the USDOT Connected Vehicle Safety Pilot Program. Ideally, the Freight ITS Working Group would work collaboratively with state and local government agencies and private industries to address real-world challenges and share the results of its efforts with transportation stakeholders. The group would continually strive to gain a compre-

hensive understanding of the challenges facing freight transportation community in Michigan, and to define, develop, test, and evaluate creative ways to pursue greater overall freight system efficiency and productivity. More specifically, the working group would:

- Cooperatively analyze the intermodal freight transportation system in Michigan and identify physical and information exchange bottlenecks
- Explore solutions to challenges across all modes and identify key technology program areas (e.g., border-crossing operations, freight corridor management, commercial vehicle operations, advanced fleet management, congestion mitigation, managing manufacturing supply chains, etc.)
- Develop pilot freight ITS demonstrations through public private partnerships, similar to the I-94 Truck Parking Management and Information System, when new opportunities emerge, such as progress associated with the new international trade crossing project in Detroit, and the ongoing federal Smart Roadside Program
- Share information, best practices, and lessons learned with the freight community at large

Many transit agencies have already implemented various ITS programs into their operations. Most have the ability to track buses in real-time, and many are using some form of demand-responsive dispatching. State-level guidance and coordination on the deployment of such technologies combined with integrated corridor management could improve service for multiple transit modes. For example, transit agencies using advanced ITS systems could deploy vehicles in real-time response to waiting passengers or even reservations. Vehicles could move efficiently through cities by communication with infrastructure and receiving signal priority. Interoperable systems could facilitate inter-

agency coordination, allowing travelers to seamlessly transfer from the services of one transit agency to another.

Freight and transit ITS systems are broad and multifaceted. Many factors will influence the use of ITS technologies and the development of corresponding information systems, such as functionality, costs, mode, geographic coverage, and private sector involvement. The development a state-level ITS information system has three options:

- Single-application approach: In this case, the data elements are organized and integrated for a specific ITS application or business process (e.g., commodity flows).
- Intermediate approaches: In this case, the data elements are organized and integrated for a specific set of applications at the state, regional, and local levels. For example, an intermediate implementation approach could include commodity flows, safety, and pavement impacts.
- Holistic, all-encompassing approach: In this case, the data elements are organized and integrated for all freight and/or transit transportation-related applications or business processes at the state, regional, and local levels.

For any of these implementation options, the data architecture would include the necessary set of tools that describe related functions or roles, components where those roles reside or apply, and data flows that connect roles and components.

The complexity of implementing projects across multiple borders and jurisdictions can often add considerable cost to a project, or even prevent otherwise tenable projects. The State of Michigan and MDOT have a broader scope of consideration and responsibility than local jurisdictions. For example, if the transit vehicle signal prioritization was a component of a larger, scalable, interoperable traffic management system, the additional benefits could far outweigh the marginal costs of the larger system. Municipal emer-

gency and law enforcement vehicles could also be given signal prioritization. With ITS integrated signals, automated demand-responsive traffic control is only a step away. Such an expanded system could benefit every user of the corridor. Even the surrounding area and environment could benefit as there could be less pollution associated with a more efficient, broadly integrated Intelligent Transportation System.

Several factors should be considered in prioritizing ITS projects that may be difficult to capture in a standard cost-benefit analysis. For example, MDOT is uniquely positioned to promote cross-municipal cooperation through targeted funding and grants. Projects that may not otherwise occur could be stimulated in this way. Also, MDOT has organizational capacity to be able to consider investments that could pay off long term. ITS installations could be tacked on to scheduled maintenance and upgrade projects in anticipation of future benefits. Many transit agencies use proprietary closed-loop systems for radio communications. Very few agencies plan on upgrading their system, because they anticipate few benefits. However, if they were to upgrade to an interoperable system based on national architectures and standards, then it is only a matter of cooperation to develop interagency fare systems, scheduling, routing, etc.

The movement of people (transit) and things (freight) is the lifeblood of an economy. A dysfunctional transportation system can stop economic activity like a clogged artery can stop a heart. In an era of tight budgets and extensive regulation, the improvement and expansion of transportation must be an innovative and strategic effort. Intelligent Transportation Systems will be crucial to developing the current tangle of freight and transit schemes into a coherent system. The State of Michigan and MDOT should maintain continual cooperation with municipal and federal partners to deploy ITS systems that are strategic, interoperable, and considerate of fu-

ture developments.

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