

New York State Department of Transportation

Intelligent Transportation System (ITS) Study for the Buffalo and Niagara Falls Metropolitan Area Erie and Niagara Counties, New York

FUNCTIONAL REQUIREMENTS

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1.0 INTRODUCTION

1.1 SCOPE

1.1.1 Overview of this Project

This paper is the fourth in a series that together will comprise an Intelligent Transportation System (ITS) Study for the Buffalo / Niagara Falls region. Working Paper # 1, Transportation Systems and Deficiencies, highlighted characteristics of the regional transportation system, plus problems within that system based on input from area transportation providers and users. Working Paper #2, Initial Identification of Institutional Issues, gave an initial survey of the agency and interorganizational barriers that impede the transportation system. Working Paper # 3, Objectives, Performance Criteria & User Service Plan, identified user services and developed a user service implementation time frame.

1.1.2 Goals of this Document

This document presents the market packages for the deployment of the Buffalo/Niagara Falls area user services. Each market package is presented in terms of technologies and functional requirements. It is these technologies and functional requirements that will provide the basis for system architecture.

1.1.3 Intended Audience

This paper will be reviewed by the Critical Stakeholders for input to the functional requirements and market packages presented herein. The system architects will use this paper to develop system interface and data requirements.

1.1.4 Document Organization

Section 2 provides background information on each of the market packages and their required technologies. Section 3 relates the market packages specific to the Buffalo/Niagara Falls area to their component user services and the technologies necessary to implement each market package. Section 4 provides the Functional Requirements for each category of the market packages. These categories are Advanced Traffic Management System (ATMS), Advanced Traveler Information System (ATIS), Commercial Vehicle Operations (CVO), Emergency Management (EM), ITS Planning, Advanced Public Transportation System (APTS) and Advanced Vehicle Safety Systems (AVSS).

1.2 ACRONYMS, AND ABBREVIATIONS

APTS- Advanced Public Transportation Systems

ATIS- Advanced Traveler Information Systems



ATMS-	Advanced Transportation Management Systems
AVSS-	Advanced Vehicle Safety Systems
CCTV-	Closed Circuit Television
CVO-	Commercial Vehicle Operations
EM-	Emergency Management
IEEE-	Institute of Electronic & Electrical Engineers
ISP-	Information Service Provider
NEMA-	National Electronic Manufacturers Association
NTCIP-	National Transportation Communications for ITS Protocol

1.3 PROPOSED STANDARDS

Systems should be compatible with industry wide standards such as those developed by IEEE and NEMA. Compliance with NTCIP and the national system architecture currently under development is also recommended.



2.0 DEFINITION OF FUNCTIONAL AREAS

2.1 MARKET PACKAGE DEFINITION

Market packages have been defined within the National ITS Architecture Program. They address specific service requirements of various ITS stakeholders and consider the transportation architecture, communication infrastructure and institutional issues. The Program is flexible and accommodates a range of possible ITS implementations throughout the nation over a twenty year time frame. Market packages are designed separately or in combination to solve real world transportation problems and needs. Market packages are inter-related and are also dependent on external factors such as technology advancement, policy change, and development of common interface standards. They provide different benefits, different cost recovery mechanisms, and are subject to different levels of market influence.

Market packages are grouped into the functional areas of Advanced Traffic Management Systems (ATMS), Advanced Traveler Information Systems (ATIS), Commercial Vehicle Operations (CVO), Emergency Management (EM), ITS Planning, Advanced Public Transportation Systems (APTS) and Advanced Vehicle Safety Systems (AVSS). Definitions of the market packages, as outlined in the National ITS Architecture Program, follow. Additionally, market packages developed specifically for the Buffalo/Niagara Falls area are also presented below.

2.1.1 ATMS Market Packages

Network Surveillance (ATMS1) Market Package. This market package implements fixed roadside surveillance elements and the communication infrastructure to transmit the surveillance data to traffic management centers. It can be used for loop detection, signal control, or CCTV that send back data to traffic management centers. This enables traffic managers to monitor road conditions, identify and verify incidents, analyze and reduce collected data, and make it available to users and private information service providers.

Probe Surveillance (ATMS2) Market Package. This allows for mobile surveillance elements to transmit surveillance data information to the traffic management center. As an additional component to network surveillance, it enables traffic managers to monitor road conditions, identify and verify incidents, analyze and reduce collection data, and make it available to users and private information providers. Probe equipment is installed in private vehicles. In return, the vehicle owners subscribe to a service to receive personalized travel data. The user may have the ability to turn off the probe functions to ensure individual privacy. The electronic toll collection tags used within the EZ-Pass system could be used as probe equipment and facilitate deployment of a probe surveillance market package.

Surface Street Control (ATMS3) Market Package. This allows for communication links and for signal control equipment to have complete local surface street and/or arterial traffic control (i.e. arterial signalization control). This market package is considered as a intra and inter-jurisdictional package and is consistent with typical urban traffic signal control systems. *This market package can*



benefit from the deployment of the Buffalo/Niagara Falls specific Institutional Management Market Package.

Freeway Control (ATMS4) Market Package. This market package facilitates implementation of ramp, lane and interchange controls for freeways. This is consistent with typical urban traffic freeway control systems and incorporates the instrumentation included in the Network Surveillance Market Package that supports freeway monitoring with optional adaptive strategies. Several more advanced Market Packages build on the fundamental infrastructure and control strategies supported by this market package. The equipment associated with incident detection that is distributed along the roadway and included within the traffic management center is separately identified within the architecture so that incident detection may be considered and analyzed as an elective based on local needs and preferences.

HOV and Reversible Lane Management (ATMS5) Market Package. This includes the management of HOV lanes by coordinating freeway ramp meters and connector signals with HOV lane usage signals. This market package also provides traffic managers the capability to access and manage reversible lane controls using vehicle occupancy detectors that identify HOV vehicles. Additional hardware and software is required to process traffic information, control reversible lane activities and reconfigure intersections that manage dynamic demand changes and special events.

Traffic Information Dissemination (ATMS6) Market Package. This market package allows information to be disseminated via VMS and/or HAR and does not require a vehicle to have any special-purpose equipment (i.e., AM radio used for receiving HAR broadcast). This market package can supplement an incident management plan. This Package could also ensure that information is available in a format for media usage, such as fax output or direct tie-in to radio and television station computer systems.

Regional Traffic Control (ATMS7) Market Package. This package allows traffic information and control to be shared between traffic management centers to support a regional control strategy. This market package relies on roadside instrumentation supported by the Surface Street Control and Freeway Control market packages. The nature of optimization and extent of information and control sharing is determined through working arrangements between jurisdictions. Additional hardware, software and wireline communications capabilities are added to implement coordinated traffic management measures (i.e., metering, signalization, coordination). *This market package can benefit from the deployment of the Buffalo/Niagara Falls specific Institutional Management Market Package.*

Incident Management System (ATMS8) Market Package. This market package manages both predicted and unexpected incidents so that the impact to the transportation network and traveler safety is minimized. Requisite incident detection capabilities are included in the Freeway Control Market Package and through regional coordination with other traffic management and emergency management centers. Information from these diverse sources is collected and correlated within this package to detect and verify incidents. It shares information with Emergency Response Market package to enable coordination. The response may include traffic control strategy modifications and



presentations of information to affected travelers using technologies included within the Traffic Information Dissemination Market Package. The same equipment may assist operators by monitoring an incident status as the response unfolds. Coordination with the Emergency Response Market Package might be through a CAD system or through communication with emergency field personal.

Traffic Network Performance Evaluation (ATMS9) Market Package. This market package supports advanced algorithms for historical evaluation, real-time assessment and forecast of traffic network performance. This includes the predictions of travel demand patterns and travel times for route planning. In addition, interface with transportation planners is required. This Market package provides data that supports the implementation of TDM programs, and policies managing both traffic and the environment. Information on vehicle pollution levels, parking availability, usage levels and vehicle occupancy are collected by monitoring sensors which have been implemented as part of this market package or through other surveillance packages.

Dynamic Toll/Parking Fee Management (ATMS10) Market Package. This market package shares functionality with the Electronic Clearance, In-Vehicle Signing and the Probe Surveillance Market Packages. This market package gives toll operators the capability to electronically collect tolls and detect violators. It provides highway authorities the ability to implement demand management strategies. Two-way short range communication with vehicles (tag or beacon) is required as well as wireline interfaces to traffic management and billing systems. This Market package also allows a parking facility to manage its parking operations, coordinate with transportation authorities and collect parking fees. This is performed by sensing/collecting parking data and sharing it with information providers and traffic management subsystems.

Emissions and Environmental Hazards Sensing (ATMS11) Market Package. This provides monitoring of emissions levels using roadway sensors to collect data. This market package may be integrated with other surveillance infrastructure deployed through the Network Surveillance Market Package. This Package may include machine vision-based equipment to identify violators' license plates for appropriate actions, sensors to detect environmental hazards (i.e., icy roads, dense fog), and communications equipment to transmit data to the traffic operations center. The gathered information can be used to implement environmentally sensitive transportation programs, policies, and regulations.

Virtual TMC and Smart Probe Data (ATMS12) Market Package. This allows the locality the capability of accessing available information for roadway conditions. This package uses vehicles as smart probes capable of measuring road conditions and in-vehicle signing to detect roadway conditions. Probes may be distributed over a very wide area (e.g., a whole state or collection of states). This market package is an enhancement of the Probe Surveillance Market package.

2.1.2 ATIS Market Packages

Broadcast Traveler Information Market Package (ATIS1). This involves the collection of traffic conditions, roadway conditions, parking information, and public transit information which is disseminated in near real-time over a wide area through existing infrastructures using low cost



equipment. This package can support dynamic route guidance. Deployment of this market package relies on availability of real-time transportation data from the various roadway technologies, probe vehicles, and/or other applications.

Interactive Traveler Information Market Package (ATIS2). This allows the user to request and obtain current information regarding traffic conditions, transit services, traveler services, ride share/ride match, and parking management. To support the required digital communications between a traveler and the information service provider, a range of two-way wide-area wireless and wireline communications systems are required. Interactive devices include kiosks, Personal Digital Assistants, telephones, computers and various in-vehicle devices. Successful deployment relies on the availability of real-time transportation data from other roadway technologies such as vehicles probes, traffic centers, and other roadway instrumentation. The Information Service Provider (ISP) Based Route Guidance Market Packages can utilize components of this market package. Additionally, this market package can use the information provided by the Transit Passenger and Fare Management Market Package as well as the Dynamic Toll/Parking Fee Management Package.

Autonomous Route Guidance Market Package (ATIS3). This enables route planning and detailed route guidance based on static information. Location data sources and map providers can provide position fixes and map updates for in-vehicle and personal route guidance. Capabilities identical to in-vehicle route guidance are available to the traveler outside the vehicle by integrating similar types of equipment into portable devices. Communication with the infrastructure is not assumed or required. Autonomous Route Guidance, Dynamic Route Guidance and Information Service Provider-Based Route Guidance are representative of the private sector role in ITS investments.

Dynamic Route Guidance Market Package (ATIS4). This offers the user real-time advanced route guidance. This package combines the Autonomous Route Guidance Package user equipment with a digital receiver capable of receiving real-time traffic, transit, and road condition information. Equipment used for this package is a provision of route guidance.

Information Service Provider-Based Route Guidance Market Package (ATIS5). This moves the route planning function from the user device to the information service provider enabling demand management. This package includes two-way data communications and can equip the user with a database, location determination capabilities, and display technologies that will support turn-by-turn route guidance.

Integrated Transportation Management/Route Guidance Market Package (ATIS6). The coordination between the Information Service Provider and the Traffic Management System allows continuous optimization of traffic control strategies based on near real-time information on intended routes for a proportion of the vehicles within the network. It provides route planning information to optimize traffic management strategies while at the same time providing updated signal timing information back to the Information Service Provider to allow for optimized route plans.



Yellow Pages and Reservation Market Package (ATIS7). This builds on the Interactive Traveler Information Market Package by adding yellow pages and reservation capabilities infrastructure. It allows for various functions to access information prior to a trip or while en-route in a vehicle. Service or advertising fees should allow for recovery of the Information Service Provider investment.

Dynamic Ridesharing Market Package (ATIS8). This market package enhances the Interactive Traveler Information Market Package by adding infrastructure capability without increasing the driver or traveler investment. Service fees may be assessed to recover a private Information Service Provider's investment. Equipment requirements are similar to the Yellow Pages and Reservation Market Package.

In-Vehicle Signing (ATIS9) Market Package. This market package supports local distribution of information regarding immediate roadway conditions such as weather, congestion, and accidents. This package includes capabilities for connections to the Traffic Operations Center for coordination and control. This market package can use the same dedicated, short-range communications as the Dynamic Toll/Parking Fee Management Market Package.

2.1.3 CVO Market Packages

Fleet Administration Market Package (CVO1). This market package shares common tracking, management and dispatch capabilities with Freight Administration, CVO Fleet Maintenance, and HAZMAT Management Market Packages. Vehicle locations, itineraries, and fuel usage can be tracked and relayed to the Freight Management Center. The vehicle has a processor and sensors interfaced to the data link. Fleet and Freight Management Centers can provide vehicles with dispatch instructions and can respond to requests for assistance and general information from the vehicle via the data link.

Freight Administration Market Package (CVO2). Interconnections are provided to intermodal shippers and intermodal freight depots for tracking the cargo from the origin to the destination. Interfaces are provided to an Information Source Provider to calculate optimum cargo routing.

Electronic Clearance Market Package (CVO3). This market package provides for automated clearance at roadside check facilities. The roadside check facility communicates with the Commercial Vehicle Administration subsystem over wireline to retrieve infrastructure snapshots of critical carrier, vehicle and driver data to be used to sort passing vehicles. Transponders and dedicated short-range communications to the roadside are necessary technologies. This market package may also incorporate automatic vehicle identification (AVI), weighing sensors, transponder read/write devices, computer workstation processing hardware, software and databases.

Electronic Clearance Enrollment Market Package (CVO3a). This market package allows registration of drivers, vehicles and carriers through an electronic credential and tax filing system. This market package maintains current profile databases in the Commercial Vehicle Administration Subsystem. This database is accessible by the commercial vehicle check facilities at the roadside to support the electronic clearance process.



International Border Electronic Clearance (CVO4). This market package provides for automated clearance specific to international border crossings. This package augments the electronic clearance package by allowing interface with customs related functions and permitting NAFTA required entry and exit from the US to Canada (and Mexico).

Weigh-In-Motion Market Package (CVO5). This provides a high speed weigh-in-motion with or without an AVI attachment. This package provides roadside equipment, either fixed or removable. If this equipment is fixed, then it is considered as a part of the Electronic Clearance Market Package and perform alongside the AVI and advanced vehicle control (AVC) equipment in place.

Roadside CVO Safety (CVO6). This market package supports automated commercial vehicle safety inspection for commercial vehicle checks through monitoring and reporting functions. This market package may utilize input from the Electronic Clearance Market Package and the On-Board CVO Safety Market Package.

On-Board CVO Safety (CVO7). This market package provides for on-board commercial vehicle safety monitoring and reporting. It is an enhancement for the Roadside CVO Safety Market Package and includes roadside support for reading on-board safety data via tags. Communications links can be the same as the Roadside Safety Market Package and provides data and/or voice links to the Fleet and Freight management and the Emergency Management Centers.

CVO Fleet Maintenance (CVO8). This market package maintains records of vehicle mileage, repairs, and safety violations to ensure safe vehicles on the roadway. An interface is required between on-board monitoring equipment and automatic vehicle location equipment (AVL) devices and the Fleet and Freight Management Center.

HAZMAT Management Market Package (CVO9). This market package provides HAZMAT spill notification to the Emergency Response Market Package. As traffic management system (TMS) incident management capabilities are integrated with commercial vehicle tracking, credentials management, and safety, HAZMAT materials and incidents can be effectively monitored.

2.1.4 EM Market Packages

Emergency Response Market Package (EM1). This automates emergency vehicle notification and verification of incident, location, and nature of incident by integrating the Mayday Support, Transit Security and Incident Management Market Packages.

Emergency Routing Market Package (EM2). This provides support for dynamic routing of emergency vehicles and coordination with the Traffic Management Center for green wave function and the Information Service Provider for the best route. This market package may be a special application of the ISP Based Route Guidance Market Package.



Mayday Support Market Package (EM3). This allows the user to initiate a request for emergency assistance which signals the Emergency Management Center to dispatch the needed types of emergency vehicles. The request may be manually initiated or automatically linked to the vehicle sensors. The data is sent to the Emergency Management Center using a wireless data link with voice as an option. A technology within the user device or a location determination by the communication infrastructure is needed to obtain the user's location.

2.1.5 ITS Planning Market Packages

ITS Planning (ITS1). This supports ITS planning functions and accepts data to plan new deployments and new market packages as well as supporting policy decision making, allocation of funding and resources and, other planning activities.

Institutional Management (Buffalo Specific). This market package supports information sharing between agencies to develop a regional market package deployment. This market package enhances the Multi-modal Coordination Market Package to provide the infrastructure necessary for database access and shared control.

2.1.6 APTS Market Packages

Transit Vehicle Tracking Market Package (APTS1). With the use of an AVL system, transit vehicles can be tracked in real-time providing the vehicle's position and schedule adherence. The information can be relayed to the infrastructure or may be determined directly by the communications infrastructure. A two-way wireless communication link with the transit management center is used for transmitting the vehicle position and control measures. The transit management center processes the information, updates the transit schedule and makes real-time schedule information available to the public.

Transit Fixed-Route Operations Market Package (APTS2). This provides automatic driver assignment and monitoring, as well as vehicle routing and scheduling for fixed-route service using an existing AVL database as a source for current schedule performance data. The service is implemented through data processing and information displays with data being exchanged using existing wireline to the information provider.

Demand Response Transit Operations Market Package (APTS3). This achieves automatic driver assignments, monitoring, vehicle routing and scheduling for demand responsive transit services. It uses an existing AVL database to monitor the current status of the transit fleet and provides support to allocation of incoming service requests. Necessary data processing and information displays can assist the transit operator in making optimal use of the transit fleet. Traveler equipment is also included within this package that enable traveler requests for flexible route transit and paratransit service. The Information Service Provider that provides the interface to the traveler devices may be either part and parcel of the transit management center or be independently owned and operated by a separate service provider. A traveler can make a direct request to a specific paratransit service, or a third party service provider can determine paratransit



service is a viable means of satisfying a traveler request and can use wireline communications to make reservations for the traveler.

Transit Passenger and Fare Management Market Package (APTS4). This allows for the management of passenger loading and fare payments on-board vehicles using electronic technologies. The payment device may be a credit card or an electronic card with stored value capabilities. Sensors mounted on the vehicle permit the driver and central operator to determine vehicle loads, and readers are located in the infrastructure or on-board the transit vehicle that determine the fare payment. The data is processed, stored and displayed on the transit vehicle and communicated as needed to the Transit Management Center using existing wireless infrastructure. This market package may be integrated with the Dynamic Toll/Parking Management Market Package to help achieve a multi-modal system.

Transit Security Market Package (APTS5). This allows for the physical security of the transit passengers with an on-board security system that performs surveillance and warns of potential hazardous situations. Transit areas such as park and ride lots, stations, and stops are also monitored. Information is communicated to the transit management center using existing or emerging wireless (vehicle to center) or wireline (area to center) infrastructure. Security related information is also transmitted.

Transit Maintenance Market Package (APTS6). This market package supports automatic maintenance scheduling and monitoring using on-board condition sensors. The sensors provide critical system status information to the transit management center. Hardware and software in the transit management center process this data and develop required maintenance schedules.

Multi-modal Coordination Market Package (APTS7). Two-way communications between multiple transit and traffic agencies improve service coordination, operating efficiency, and intermodal coordination and increase traveler convenience at transfer points.

2.1.7 AVSS Market Packages

Vehicle Safety Monitoring Market Package (AVSS1). This market package shares functions with the Driver Safety Monitoring, Longitudinal Safety Warning, Lateral Safety Warning and Intersection Safety Warning Market Packages. The functions for this market package includes sensing devices, processing algorithms, processors, status and warning displays.

Driver Safety Monitoring Market Package (AVSS2). This market package includes sensing devices to monitor driver conditions in regard to the driving characteristics to prevent impaired performance.

Longitudinal Safety Warning Market Package (AVSS3). This market package shares common sensory functions with the Advanced Vehicle Longitudinal Control Market Package. The sensing and detecting of obstacles in the longitudinal direction performed in this market package is directly applicable to the Advanced Vehicle Longitudinal Control Market Package.



Lateral Safety Warning Market Package (AVSS4). This market package shares common sensory functions with the Advanced Vehicle Lateral Control Market Package. The sensing and detecting of obstacles in the longitudinal direction performed in this market package is directly applicable to the Advanced Vehicle Lateral Control Market Package.

Intersection Safety Warning Market Package (AVSS5). This market package has common functions with the Intersection Collision Avoidance Market Package. The sensing and detecting of obstacles and conditions in the vicinity of an intersection and communicating this information to on-coming vehicles performed in this market package is directly applicable to its successor, the Intersection Collision Avoidance Market Package. This market package is a logical extension of the In-Vehicle Signing Market Package.

Pre-Crash Restraint Deployment Market Package (AVSS6). This market package provides a pre-crash restraint deployment system. It requires the sensing and detecting technologies for the various safety warning market packages as well as the Collision Avoidance Market Packages.

Driver Visibility Improvement Market Package (AVSS7). This market package provides an enhanced vision system. On-board display hardware is needed.

Advanced Vehicle Longitudinal Control (AVSS8). This market package shares common functions with the Pre-Crash Restraint Deployment and Automated Highway System Market Packages. The capability to sense, detect, and act based upon longitudinal detection is a requirement for the Pre-Crash Restraint Deployment Market Package. This market package provides those functionalities that would be integral to the Pre-Crash Restraint Deployment Market Package. Complete automated control of the vehicle is an extension of this package (and Lateral Control).

Advanced Vehicle Lateral Control (AVSS9). This market package shares common functions with the Pre-Crash Restraint Deployment and Automated Highway System Market Packages. The capability to sense, detect, and act based upon lateral detection is a requirement for the Pre-Crash Restraint Deployment Market Package. This market package provides those functionalities that would be integral to the Pre-Crash Restraint Deployment Market Package. Complete automated control of the vehicle is an extension of this package (and Longitudinal Control).

Intersection Collision Avoidance (AVSS10). This market package builds on the Intersection Safety Warning Market Package infrastructure and in-vehicle equipment and adds equipment to the vehicle that can take control of the vehicle in the event of an imminent collision. A short-range communications system is used to provide information to the vehicle regarding location and speeds near an intersection.

Automated Highway System (AVSS11). This market package enables non-driver automated operation of the vehicle on an automated portion of a roadway. Implementation requires lateral lane holding, vehicle speed and steering control as well as data interchange between the vehicle and the automated highway system.



2.2 DEFINITION OF FUNCTIONAL ELEMENTS

Market package can be defined in terms of Technology Areas (sensor, communications, interface, and control applications).and broken down into requirements, features, associated issues, and required/desirable functionality within short, intermediate, and long-term time frames for deployment. These areas either have a basic (primary) or secondary (supporting) relationship to the core services provided by the market package. The following lists the technology areas and requirements.

2.2.1 Sensors

Traffic sensors monitor overall traffic conditions while collecting basic measurements such as occupancy, volume, and speed. Technologies available are considered mature.

Rail sensors monitor train traffic as well as vehicles stopped on the tracks. This enables rail line traffic to be monitored while increasing rail line and roadway safety.

Vehicle Status sensors determine individual characteristics of passing vehicles such as vehicle length, weight, number of axles, lane position, and speed. Emissions and passenger counts enforcement technologies, which are not as developed, are also available. Technologies available are at a mix of maturity levels.

Environment sensors monitor local climate (temperature, humidity, precipitation, wind, pollution) and road surface status (dry, wet, ice, snow). Available technologies are considered mature.

Vehicle Monitoring on-board sensors observe vehicle conditions (i.e., engine, brake, tires) and the vehicles performance. These technologies are considered mature.

Driver Monitoring sensors monitor driver conditions in regard to the driving characteristics and/or other psychophysiology symptoms associated with impaired performance. These technologies are considered mature.

Cargo Monitoring sensors monitor various indicators of cargo status. These technologies are considered mature.

Obstacle Ranging sensors detect and characterize potential obstacles (i.e., other vehicles, people) in the vehicle's vicinity. These technologies are considered immature.

Lane Tracking sensors monitor the position of the vehicle with respect to the travel lane and optionally support interpretation of travel lane geometry ahead of the vehicle. These technologies are considered immature.

Security sensors provide surveillance of, and restrict access to, secure public areas. Card readers and closed circuit cameras are examples of security sensors. These technologies are considered mature.



Location Determination sensors provide absolute position using GPS and other systems which apply trilateration to known locations. Other technologies aiding in position determination include those which measure travel path and distance from a known location. These technologies are considered fairly mature and are improving rapidly.

2.2.2 Communications

Cell-Based communications provide wide-area wireless communications, both one-way and two-way. These technologies are considered mature and are improving rapidly. Some examples of cell based communications include circuit switched cellular, CDPD and FM subcarrier.

Vehicle-Roadside provide short-range wireless communications between infrastructure and a vehicle using active radio frequency, passive radio frequency, and/or infrared technologies. These technologies are considered fairly mature and are rapidly improving.

Vehicle-Vehicle is a high data rate, short-range, reliable two-way digital communications that transmit between vehicles using RF, microwave, infrared spectrum or other means. These technologies are considered immature.

Fixed Communications are used to carry information between fixed locations; technology choices are largely dependent on local service provider or local preference for private networks. These technologies are considered mature.

Algorithms enable advanced vehicle and traffic control applications. These technologies are of mixed maturity.

Information Management allows for information storage, fusion, and retrieval that supports access to distributed heterogeneous data. These technologies are considered mature and are under going rapid innovation.

Payment technologies enable secure automated financial transactions in conjunction with information management and communications. Both contact and contactless technologies may be used. These technologies are considered fairly mature.

2.2.3 Interfaces

Driver Interface includes audio, visual, and tactile interface technologies that are appropriate for interaction with the driver during vehicle operations. Console displays, heads up displays and synthesized speech are examples of mature technologies with rapid innovations occurring in the industry. Voice input and non-distracting visual enhancement are less mature.

Traveler Interface includes audio, visual, and tactile interface technologies that are appropriate for interaction with travelers. These technologies can be portable and include hand held devices.



Additional capabilities include hard copy options are used with fixed presentation devices. These technologies are considered fairly mature.

Operator Interface includes audio, visual, and tactile interface technologies that are appropriate for interaction with system operators in communicating with travelers, drivers or other operators. These technologies are considered fairly mature.

2.2.4 Control

Signals include control signals, barriers, and other physical control devices and supporting electronics. These technologies are considered mature.

Signs include variable message signs that enable an interface for vehicle-roadside communications technologies and complementary in-vehicle displays. These technologies are considered mature.

Vehicle Control technologies include system actuators and support processing technologies. These technologies are considered immature.



3.0 DEFINITION OF FUNCTIONAL REQUIREMENTS

3.1 MARKET PACKAGE DESCRIPTION

Market packages are traceable to the User Services. A market package can include capabilities which span more than one user service. A single user service may include a range of incremental capabilities that are segregated into separate market packages so that they can be considered separately from a deployment perspective. As a result, there is not a one to one relationship between the Market Packages and the User Services.

Once a particular market package is selected for implementation, equipment packages and interface requirements are readily identified. This approach allows the service needs to be considered and emphasis to be placed on those pieces of architecture necessary to provide the selected service. Market packages are a means for deployment of ITS services relevant to the underlying architecture definitions and should not be considered as a set of requirements. Market packages are implemented using a combination of interrelated equipment within the architecture frame work and may be operated and owned by more than one stakeholder.

Using the User Services previously identified in the User Service Plan, market packages were mapped to the region-specific User Services, allowing a range of equipment options at varying capital costs and segregation of lower-risk services, to meet local technical and institutional needs.

Table 3-1 provides the relationship of the market packages to the highest priority user services from the User Services Workshop. As shown in the table, these market packages support all of the immediate term user services identified from the User Services Workshop. Several medium term user services are also supported.

3.1.1 ATMS Market Packages

Network Surveillance. The Network Surveillance package provides the base measures of on-street traffic characteristics and thus supports a number of user services directly or indirectly. The most direct support is given to the Traffic Control and Incident Management User Services, while processed surveillance data are used in the following user services: Pre-Trip Travel Information, En-Route Driver Information, Route Guidance, Travel Demand Management and En-Route Transit Information.

Probe Surveillance. Probe Surveillance supports user services very similar to those supported by Network Surveillance. Probe vehicles constitute "live" data sensors of specific travel links and paths, as well as alert the operation of specific breakdowns. Supported user services include Pre-Trip Travel Information, En-Route Driver Information, Route Guidance, Incident Management, Travel Demand Management and En-Route Transit Information.

Surface Street Control and Freeway Control/Tollway Control. These two packages are a base component of the entire Traffic Control user service, and directly support it. They also interact with



MARKET PACKAGES	HIGHEST PRIORITY USER SERVICES																						
	Pre-Trip Travel Information	En-Route Driver Information	Route Guidance	Ride Matching and Reservation	Traveler Services Information	Traffic Control	Incident Management	Public Transportation Management	En-route Transit Information	Public Travel Security	Comm Vehicle Electronic Clearance	Commercial Vehicle Administrative Process	Hazardous Material Incident Response	Commercial Fleet Management	Emergency Vehicle Management	Emergency Notification and Personal Security	Road-Weather Information Service *	Electronic Payment Services	Interorganizational/Int'l Mgmt & Coord*	Customs/Immigration Inspection & Clearance	Financial management *	Operations Management*	
ATMS																							
Network Surveillance	X	X	X			X	X		X								X						
Probe Surveillance	X	X	X				X		X														
Surface Street Control						X	X	X							X								
Freeway Control/Tollway Control						X	X	X							X								
Advanced Coordinated/Integrated Signal Control						X	X	X							X								
HOV and Reversible Lane Management		X	X			X		X															
Incident Detection System	X	X	X			X	X						X			X							
Incident Dispatch Coordination/Comm System						X	X						X										
Incident Management System	X	X	X			X	X						X										
Traffic Information Dissemination	X	X	X		X		X		X				X				X						X
Regional Traffic Control						X		X					X										
Traffic Network Performance Evaluation	X	X	X			X																	
Advanced Integrated Signal/Route Control			X	X		X	X								X								
Dynamic Toll/Parking Fee Management	X	X	X															X	X				
Traffic System Maintenance						X																	X
Smart Probe Data	X	X	X			X	X																
ATIS																							
Interactive Traveler Info	X				X												X						
Broadcast Traveler Info	X	X					X										X						
Yellow Pages & Reserv	X																						
Dynamic Ridesharing	X																						
ISP based Route Guidance	X		X														X						
Dynamic Route Guidance			X														X						
Autonomous Route Guidance			X																				
CVO																							
Freight Administration											X	X	X									X	
Fleet Administration											X			X				X					
Electronic Clearance Enrollment											X	X											
International Border Electronic Clearance											X	X							X	X			X
Weigh-in-Motion											X						X						
HAZMAT Management/Response											X	X	X						X	X			X
EM																							
Emergency Routing			X			X	X									X							
Emergency Response							X		X						X	X							
Mayday Support							X									X							
ITS PLANNING																							
Institutional Management*						X	X			X	X		X		X		X	X	X	X	X	X	X
APTS																							
Transit Vehicle Tracking	X						X		X														
Transit Fixed-Route Operations						X		X	X														
Demand Response Transit Operations	X						X	X															
Transit Passenger and Fare Management							X	X	X								X	X					
Transit Security							X		X														
Transit Maintenance							X																
Multi-modal Coordination	X	X				X		X	X										X				

* Specific to Buffalo

Table 3-1 Market Packages and Highest Priority User Services



Incident Management, Public Transportation Management and Emergency Vehicle Management by implementing appropriate traffic control strategies for each.

HOV and Reversible Lane Management. Also a base component of the Traffic Control user service, this package implements aspects of En-Route Driver Information, Route Guidance and Public Transportation Management user services.

Incident Detection System. This package is one of three primary packages implementing the Incident Management user service, and directly underlies Hazardous Materials Incident Response Emergency Notification and Personal Security. Also, outputs from it support Pre-Trip Travel Information, En-Route Driver Information, Route Guidance and Traffic Control.

Incident Dispatch Coordination/Communication System. This package, the second component of the Incident Management user service, also supports Traffic Control and Hazardous Material Incident Response services.

Incident Management System. This third component of the Incident Management user service supports the same services as the Incident Detection System package except for the Emergency Notification and Personal Security user service.

Traffic Information Dissemination. This package is the vital link to both operators and especially the traveling public for numerous user services including: Pre-Trip Travel Information, En-Route Driver Information, Route Guidance, Traveler Services Information, Incident Management, En-Route Transit Information, Hazardous Material Incident Response, Road-Weather Information Service and Operations Management.

Regional Traffic Control. Taking a broader view than surface Street Control, this package is a base component of the Traffic Control user service and supports Public Transportation Management and Hazardous Material Incident Response user services.

Traffic Network Performance Evaluation. Outputs from this package ultimately support the following user services: Pre-Trip Travel Information, En-Route Driver Information, Route Guidance and Traffic Control.

Advanced Integrated/Signal Route Control. This package is a base component of both the Traffic Control and Route Guidance user services. In addition, it supports En-Route Driver Information, Incident Management and Emergency Vehicle Management.

Dynamic Toll/Parking Fee Management. This package maps directly to the Electronic Payment Services user service and interacts with Pre-Trip Travel Information, En-Route Driver Information and Route Guidance.

Traffic System Maintenance. Traffic System Maintenance is a base component of both the Traffic Control and Operations Management user services.



Smart Probe Data. This package relates to user services essentially the same as the Probe Surveillance package with the addition of interacting significantly with Traffic Control, due the more global nature of this package.

3.1.2 ATIS Market Packages

A variety of traveler information services can be used to provide pre-trip routing and event information to travellers such that travelers have the opportunity to alter their trip patterns or modes. The traveler information market packages draw upon data from a number of other ITS sources, principally ATMS sensing. Accordingly, the quality of the traveler information services will be dependent upon the extent to which network monitoring is in place from other market packages.

Yellow pages and ride matching packages are data intensive and require a measure of outreach to travellers and businesses in order to build a comprehensive database.

Interactive Traveller Information. This market package supports the implementation of the Pre-Trip Travel Information, and Traveler Services Information user services by providing traffic information over a variety of media. This market package utilizes the traffic information available from other surveillance market packages and provides the user interfaces and data links necessary to provide this information to the public. This market package provides the necessary data pre-processing at the traffic operations center.

Broadcast Traveller Information. This market package also utilizes the traffic information available from other surveillance market packages. This market package can be implemented in conjunction with the Interactive Traveller Information Market Package and utilize the same data pre-processing at the traffic operations center. This market package would provide the interface between the traffic operations center and the VMS and HAR. Other dissemination tools could be the creation of a data link to private information providers (public radio). This market package supports the implementation of the Pre-Trip Travel Information, En-Route Driver Information, Incident Management and Travel Demand Management User Services. and Road/Weather Information Service.

Yellow Pages & Reservations. This market package provides the necessary database and user interface to provide yellow pages and reservation services. Implementation of this market package necessitates the Pre-Trip Travel Information user service.

Dynamic Ridesharing. This market package will provide a user interface to retrieve trip information as well as provide ridesharing information. A dynamic ridesharing database shall be created for this market package. Appropriate algorithms will also be created. This market package will facilitate implementation of Pre-Trip Travel Information User Service by providing travelers with information on available ridesharing opportunities.

ISP Based Route Guidance, Dynamic Route Guidance, Autonomous Route Guidance Market Packages will all necessitate traffic information being available from other surveillance market



packages. The Autonomous Route Guidance Market Package will require the least data pre-processing and algorithms will be installed in the vehicle. The Dynamic Route Guidance Market Package will require the installation of a communications link between central control and the vehicle. ISP Based Route Guidance may additionally require centralized route guidance algorithms that provide demand management and turn-by-turn route guidance to the vehicle. All will require an in-vehicle driver interface suitable to provide turn maneuver directions in some form.

3.1.3 CVO Market Packages

As shown in Table 3-3 each of the market packages in this functional category are comprised of user services found in the Immediate Term implementation time frame as developed for the Buffalo/Niagara Falls area User Services Plan. Each of these market packages requires access to the Commercial Vehicle Electronic Clearance User Service.

Freight Administration. This market package will utilize tracking, management and dispatch technologies. This market package will access the database utilized for the Commercial Vehicle Electronic Clearance user service to help track cargo from origin to destination. In addition to these tracking capabilities, tags or transponders can also be assigned to the shipping containers with readers installed at the freight depots and intermodal shipping points. In conjunction with the Commercial Vehicle Administrative Processing User Service, interconnections to the freight depots and intermodal shipping points can be implemented to collect this tracking data. The user interface provided with the Administrative Processing User Service can be used for management processes and to access optimum cargo routing programs. Cargo and shipment data can be shared with the Customs / Immigration Inspection & Clearance User Service.

Fleet Administration. This market package shares common tracking, management and dispatch capabilities with the Freight Administration Market Package described above. Additional surveillance and monitoring capabilities will be added with the Commercial Fleet Management User Service to include AVL, itineraries and fuel/tax measures to meet record keeping requirements of the various regulatory agencies.

Electronic Clearance Enrollment. This market package creates the database link to accept the electronic applications developed through the Commercial Vehicle Administrative Processing User Service. The data will then be used for the Commercial Vehicle Electronic Clearance User Service to create improved border crossing efficiency (International Border Electronic Clearance Market Package).

International Border Electronic Clearance. This market package necessitates the implementation of the Commercial Vehicle Electronic Clearance database and the data input capabilities incorporated with Commercial Vehicle Administrative Processing. This market package can use the Interorganization/International Management & Coordination user service to develop passing criteria and required information as well processing methodology. The Customs/Immigration Inspection & Clearance database will also be integrated.



Weigh-in-Motion. Using the roadside communications equipment necessary to implement the Electronic Payment User Service and adding dynamic weight sensors, the Weigh-in-Motion Market Package can incorporate weight enforcement into the Commercial Vehicle Electronic Clearance User Service.

HAZMAT Management / Response. This market package adds HAZMAT cargo content, handling and recovery instructions to the Commercial Vehicle Electronic Clearance and Commercial Vehicle Administrative Processing databases. Communication links necessary to implement the Hazardous Material Incident Response User Service will allow appropriate emergency response to a hazardous material spill. The Interorganizational/International Management & Coordination user service can be used to set safety and reporting requirements.

Roadside CVO Safety. This market package automates commercial vehicle safety inspections. The capabilities for performing the safety inspection are shared between the this market package and the On-board CVO Safety Market Package. Basic identification data could be read from an electronic tag on the commercial vehicle to facilitate an efficient roadside safety inspection.

On-board CVO Safety. This market package provides for on-board commercial vehicle safety monitoring and reporting. This market package uses the same communication links as the Roadside CVO Safety Market Package and provides the commercial vehicle with a cellular link to the Fleet and Freight Management and the Emergency Management Centers.

Fleet Maintenance. This market package supports maintenance of CVO fleet vehicles through close interface with on-board monitoring equipment and AVLS capabilities. Records of vehicle mileage, repairs and safety violations are maintained to assure safe vehicles on the highway.

3.1.4 Emergency Management (EM) Market Packages

Emergency Response. The Mayday Support, Transit Security and Incident Management Market Packages are combined in this market package. This market package also supports the Incident Management User Service as it provides the incident location and possible details of the incident. The Emergency Vehicle Management User Service can be used as the proper emergency response agency then notified given incident location and details as well as agency availability. The Public Travel Security and Emergency Notification and Personal Security User Services allow for response to public and private requests respectively.

Emergency Routing. This market package also supports the Incident Management User Service as it provides the incident location. The incident location is then used with the Route Guidance User Service to plan the most efficient route for emergency vehicles. The Traffic Control User Service is incorporated to provide a signal green wave function to reduce emergency vehicle response time.

Mayday Support. The Emergency Notification and Personal Security User Service is provided as this package notifies the Emergency Management Center with an incident call. This market package



also supports the Incident Management User Service as it provides the incident location and possible details of the incident.

3.1.5 ITS Planning Market Packages

Institutional Management. This market package provides the communications and hardware/software infrastructure for the implementation of four of the five new Buffalo area specific user services; Interorganizational/International Management & Coordination, Customs/Immigration Inspection & Clearance, Financial Management and Operations Management. This market package will provide an interface to the Traffic Control and Incident Management User Services, thus enabling them to be addressed on a regional level. The communications and hardware/software from this market package can be utilized to implement the Commercial Vehicle Electronic Clearance, HAZMAT Incident Response and Emergency Vehicle Management User Services.

3.1.6 APTS Market Packages

Transit Vehicle Tracking. The Transit Vehicle Tracking Market Package utilizes location determination and rail sensors to track vehicles on the transit network. The Public Transportation Management User Service is provided by this market package through real-time computer monitoring of transit vehicle locations. The real-time locations of transit vehicles are also used to support the Pre-trip Travel Information User Service. Transit Vehicle Tracking enables the Public Travel Security User Service by monitoring vehicle location for designated route and schedule.

Transit Fixed Route Operations. The AVL database used with this market package can be used to preempt traffic signals through integration with the Traffic Control User Service. This market package also provides the Public Transportation Management User Service through automatic driver assignments, vehicle routes and route schedules. These automatic routes and schedules are then used to provide the En-Route Transit Information User Service.

Demand Response Transit Operations. This market package uses a database containing the current status of the transit fleet to provide the Pre-Trip Travel Information and En-Route Transit Information User Services. The Public Transportation Management User Service is provided as data processing / information displays assist the transit operator in making optimal use of the transit fleet.

Transit Passenger and Fare Management. The Public Transportation Management User Service is provided as this market package allows for the management of passenger loading and fare payment on-board vehicles using electronic technologies. The Electronic Payment Services User Service can be provided through the use of credit cards or cards with value stored electronically for fare payment. The Public Travel Security User Service is provided as transit riders are not required to carry cash when using electronic payment services.

Transit Security. Systems that monitor the environment of transit vehicles, stations and stops provide for the Public Travel Security User Service. The Public Transportation Management User service is also provided through system surveillance and monitoring.



Transit Maintenance. This market package supports automatic maintenance scheduling and monitoring using on-board conditions sensors. The automatic scheduling and monitoring helps to provide the Public Transportation Management User Service by facilitating efficient maintenance.

Multi-Modal Coordinations. Provides two-way communications between multiple transit and traffic agencies. Interagency communication supports the following user services: Pre-Trip Travel Information; En-Route Driver Information; Traffic Control; Public Transportation Management; En-Route Transit Information; and Interorganizational/International Management & Coordination.

3.1.7 Advanced Vehicle Safety Systems (AVSS) Market Packages

This group of market packages to be implemented in the Buffalo/Niagara Falls utilizes Future Term User Services. Although the technologies used in the development of these market packages are considered immature, the required technologies and functional requirements are defined in later sections. It is important that these market packages be considered in the development of the system architecture in order to allow for their future incorporation. Table 3-2 below provides a correspondence between the market package and the user services. Those user services shown in *italics* are used in the development of more than one market package.

Table 3-2 AVSS Market Packages vs. User Services

AVSS Market Package	CORRESPONDING USER SERVICE
Driver Visibility Improvement	Vision Enhancement for Crash Avoidance**
Vehicle Safety Monitoring	<i>On-Board Safety Monitoring</i>
Driver Safety Monitoring	<i>On-Board Safety Monitoring</i>
Longitudinal Safety Warning	<i>Longitudinal Collision Avoidance**</i>
Lateral Safety Warning	<i>Lateral Collision Avoidance**</i>
Intersection Safety Warning	<i>Intersection Collision Avoidance**</i>
Pre-Crash Restraint Deployment	Pre-Crash Restraint Deployment
Advanced Vehicle Longitudinal Control	<i>Longitudinal Collision Avoidance**</i>
Advanced Vehicle Lateral Control	<i>Lateral Collision Avoidance**</i>
Intersection Collision Avoidance	<i>Intersection Collision Avoidance**</i>
Automated Highway System	Automated Highway System**

** Each of these user services will most likely be implemented by others. Public agency interaction will be required.



	TECHNOLOGY AREA																									
	Sensor											Comm					Interface			Control						
	Traffic	Rail	Vehicle Status	Environment	Vehicle Monitoring	Driver Monitoring	Cargo Monitoring	Obstacle Ranging	Lane Tracking	Security	Location Determination	Cell-Based (U1)	Vehicle-Roadside (U2)	Vehicle-Vehicle (U3)	Broadcast (U4)	Fixed (W)	Algorithms	Information Mgmt	Payment	Driver	Traveler	Operator	Signals	Signs	Vehicle	
MARKET PACKAGES																										
ATMS																										
Network Surveillance	X		X	X						X	O	X				X	X					X				
Probe Surveillance			X							X	X	X				X	X					X				
Surface Street Control	X		O	O						O	X	X				X	X					X	X	X		
Freeway Control/Tollway Control	X		X	O						O	X	X				X	X					X	X	X		
Advanced Coordinated/Integrated Signal Control	X		X	O						O	X	X				X	X					X	X	X		
HOV and Reversible Lane Management	X		X												X	X	X		X			X	X	X		
Incident Detection System	X		X								X					X	X					X				
Incident Dispatch Coordination/Comm System										X	X	X	X			X	X		X			X				
Incident Management System	X			O						X	O	X				X	X		X	X	X	X	X	X		
Traffic Information Dissemination										X	O	O				X	X		X	X	X	X	X	X		
Regional Traffic Control	X		X	O						O	O	O				X	X		X	X	X	X	X	X		
Traffic Network Performance Evaluation	X															X	X					X				
Advanced Integrated Signal/Route Control	X		X	O						X	X	X	X			X	X		X	X	X	X	X	X		
Dynamic Toll/Parking Fee Management	X		X						X		X	X				X	X	X	X	X		X		X		
Traffic System Maintenance																X	X					X				
Smart Probe Data			X							X	X	X				X	X					X				
ATIS																										
Interactive Traveler Info	X			O	O					X	X				X	X	X		X	X	X					
Broadcast Traveler Info	X			O	O					O	X			X	X	X	X		X	X	X			X		
Yellow Pages & Reserv										O	X				X	X	X		X	X	X					
Dynamic Ridesharing								O			X				X	X	X		X	X	X					
ISP based Route Guidance	X			O	O					X	X				X	X	X		X	X	O					
Dynamic Route Guidance	X			O	X					X	X			X		X	X		X	X	X					
Autonomous Route Guidance	X			X						X	X					X	X		X							
CVO																										
Freight Administration						X				X	X	X					X		O		O					
Fleet Administration					X					X	X	X					X		O		O					
Electronic Clearance Enrollment															X		X					X				
International Border Electronic Clearance											X	X					X	X	X	X	X					
Weigh-in-Motion												X				X	X	X	X	X	X					
HAZMAT Management/Response	O									X	O	X					O							O		
EM																										
Emergency Routing				O						X	X	X			O	O	X		X		X	O				
Emergency Response	O									X	X	X	O		X	O	X		O		X					
Mayday Support			X	X						X	X	X	O			X	X		X	O	X					
PLANNING																										
Institutional Management*	O									O					O		X				O					
APTS																										
Transit Vehicle Tracking					O	O				X	X	O			O	O	X	X		O	O	X				
Transit Fixed-Route Operations		O		O						O	O	O		O	O	O	X	X		O	O	X	O			
Demand Response Transit Operations		O		O											O	O	X	X		X	O	X				
Transit Passenger and Fare Management									O	O	O						X	X		X	X					
Transit Security									X	O	O						O	O		X	X					
Transit Maintenance					X	O				O	O				O	O	X		X		X					
Multi-modal Coordination		O		O						X	X				X	O	X	O	X	O	X					
AVSS (1)																										
Driver Visibility Improvement						O		X													X					
Vehicle Safety Monitoring					X											O					X					
Driver Safety Monitoring					X	X										X					X					
Longitudinal Safety Warning					X	O		X								X					X					
Lateral Safety Warning					X	O		X	X							X	X				X					
Intersection Safety Warning	O	O	X	O	X	O		X	X		O	X	O		X	X	X		X				O	O		
Pre-Crash Restraint Deployment					X	O		X								X					X				X	
Advanced Vehicle Longitudinal Control					X	O		X								X					X				X	
Advanced Vehicle Lateral Control					X	O		X	X							X					X				X	
Intersection Collision Avoidance	O	O	X	O	X	X		X	X		O	X	O		X	X	O		X				O	O	X	
Automated Highway System	O	X	O	X	X			X	X	O		X	X	X	X	X	X	O	X		X		X	O	O	X

* Specific to Buffalo KEY: X = Primary O = Supporting
 (1) Although AVSS is a future implementation category, applicable technologies are included here so that the system architecture can accommodate them in the future.

Table 3-3 Market Packages & Primary and Supporting Technology Areas



3.2 MARKET PACKAGE TECHNOLOGIES

Each of the Market Packages can be broken down into the various technology defined in Section 2.2. These technologies cover the spectrum from data collection to dissemination and are grouped as follows: Sensors, Communications, Interfaces and Control. The Market Package can be implemented using a combination of interrelated equipment within the architecture framework. The Market Packages may be owned and operated by more than one stakeholder. Table 3-3 shows the primary and supporting technology areas for each Market Package.



4.0 FUNCTIONAL REQUIREMENTS

The following section provides a description of the functional requirements for each technology area. The Advanced Traffic Management System (ATMS) functional requirements are provided in Table 4-1. Tables 4-2 through 4-6 provide a listing of the functional requirements for the Advanced Traveler Information System(ATIS), Commercial Vehicle Operations (CVO), Emergency Management (EM), ITS Planning, and Advanced Public Transportation System (APTS) areas, respectively. Technologies are grouped into four application areas, as applicable, providing requirements for how data is collected, how data is transmitted, what user interfaces are required and what controls are necessary. Within each of these categories, various applications are defined. The requirements, features and any issues associated with a respective technology for each of these application areas are listed in the second column of the tables.

In Tables 4-1 through 4-6 the Functional Requirements are prioritized as Required, Desired, or Not Needed (third column). This priority was derived from input from the critical stakeholders. In total, nine of 24 critical stakeholder organizations responded via a written survey.

Table 4-7 provides a listing of the Advanced Vehicle Safety System (AVSS) functional requirements. This category was not rated by the critical stakeholders as the functionality of these market packages will be determined by private manufacturers as the needed technologies progress and a market for these products develops.

4.1 REQUIRED AND DESIRED FEATURES

According to the respondents, required features include incident management and the functions/features necessary to support widespread and complete incorporation of incident and congestion management programs. The categories of ATMS, ATIS and EM provide most of the features to support a complete implementation of an incident management program. In fact, those features that are required in ATMS and ATIS categories all support Incident and Congestion/Event Management.

CVO required features are more varied than the ATMS/ATIS categories, indicating the importance of CVO to the region. For capacity improvements, electronic payment of tolls and fees is required as well as the management of border credentials. Safety requirements include HAZMAT management and incident response requirements as well as weight, width, height and classification transmission to the roadside via vehicle to roadside communications.

EM requirements include sensors, vehicle location items and an E-911 call-in system. Respondents indicated the need for comprehensive communications and interface capabilities to support EM.

Requirements of the ITS Planning category, per the respondents, (Table 4-5) include wireless transmission of incident response status and HAZMAT cargo information. HAZMAT cargo management is also required. The operator interface is also required to provide a database interface for traffic control and incident management and response features.



Respondents identify the APTS category as requiring the detection of rail presence for pre-emption and warning. Communications between the transit vehicle driver and the dispatcher is also required as well as a direct link to the E-911 system from both drivers, dispatchers and transit stations.

4.2 NOT NEEDED FEATURES

As shown in Tables 4-1 through 4-6, the majority of features listed are Required or Desired for implementation in the Buffalo/Niagara Falls region, according to the critical stakeholders. Those features which are Not Needed in the area are described next.

Toll system features that are not desired include a closed system of toll collection, road pricing for toll collection, and implementation of a central database for electronic toll collection transaction data.

Other system features that are not desired include carpooling or dynamic ridesharing, plus dynamic route guidance for individual travelers and transit vehicles. As shown in Table 4-1, the surface street system should be instrumented to collect volumes, occupancies and speeds for traffic management purposes. Table 4-2 indicates that this data should be collected to a lesser extent than at 1-minute intervals and 300' back of intersections. Respondents want travelers to be able to access the current congestion, incident, events, transit schedules and fare information via either wireline or wireless communications media. However, the map database aspect of this information is not desired.

On the commercial vehicle operations side of system implementation, respondents do not want collection or database management of mileage and fuels information.

4.3 CRITICAL STAKEHOLDER COMMENTS

There were several comments from the critical stakeholders that warrant mentioning here. With respect to determining vehicle location, two respondents felt that this would be necessary only in the case of incident and emergency situations. One critical stakeholder proposed that the ability to determine vehicle location, specifically for incident detection, should also include low-tech solutions such as service patrols.

With respect to the ability to communicate between a traveler and the emergency management dispatcher, one critical stakeholder cautioned that the interface only allow limited capability. This security feature would protect the system from being corrupted.



Table 4-1 ATMS Functional Requirements

Technology	Requirement/Feature/Issue	Summary of Agency Response
SENSORS		
Traffic	Record volume, occupancy and speed for: <ul style="list-style-type: none"> • Monitoring congestion/detecting incidents • Controlling traffic on surface streets and freeways • Evaluating performance 	Required Desired Desired
Vehicle Status	Classify vehicles by measuring length/weight/no. axles for: <ul style="list-style-type: none"> • Monitoring congestion • Controlling traffic on surface streets and freeways • Evaluating performance 	Desired Desired Desired
Environment	Monitor temperature/humidity/precipitation, plus road surface condition (dry/wet, icy/snow-covered) to assist in: <ul style="list-style-type: none"> • Controlling traffic on surface streets and freeways 	Desired
Vehicle Monitoring	Track points of vehicle entry/egress to toll system (closed system only).	Not Needed
Cargo Monitoring	Receive carrier or cargo attributes: <ul style="list-style-type: none"> • HAZMAT • Waybill information 	Desired Desired
Security	Provide secure account processing features: <ul style="list-style-type: none"> • automatic credit card prepayment • automatic account debiting Ensure privacy of information: <ul style="list-style-type: none"> • account status • travel patterns 	Desired Desired Desired Desired
Location Determination	Determine individual vehicle location to assist in: <ul style="list-style-type: none"> • Monitoring congestion • Controlling surface streets and freeways • incident management response and 	Desired Desired Required



Table 4-1 ATMS Functional Requirements

Technology	Requirement/Feature/Issue	Summary of Agency Response
COMMUNICATIONS		
Wireless (RF, cellular, etc.)	Two-way and one-way communication in support of: <ul style="list-style-type: none"> • Monitoring congestion • Controlling surface streets, freeways & parking facilities • Disseminating traffic information Communicate account transaction data to motorist enroute.	Required Desired Desired Desired
Vehicle-Roadside	Provide short-range communications in support of: <ul style="list-style-type: none"> • Monitoring congestion • Managing incidents • Traffic information dissemination Road pricing	Desired Required Desired Desired
Vehicle-Vehicle	Provide high data rate communications between vehicles for: <ul style="list-style-type: none"> • Incident coordination/management • Traffic information dissemination 	Desired Desired
Broadcast	Wide-area one-way information broadcasts for: <ul style="list-style-type: none"> • Incident coordination/management • Traffic information dissemination 	Required Desired
Fixed	Provide one-way and two-way communications between fixed locations in support of: <ul style="list-style-type: none"> • Monitoring congestion • Detecting and managing incidents • Controlling traffic on surface streets and freeways Transmit ETC transaction data and enforcement images to central from remote toll sites. Transmit road pricing schedules from central to remote toll sites.	Desired Required Desired Not Needed Not Needed
Algorithms	Mathematical techniques for compiling data, solving control problems, and determining optimal routing. Used in all ATMS Market Packages.	Desired
Information Management	Computer-based techniques for executing algorithms plus managing data and databases, used in all ATMS Market Packages.	Desired
Payment	Support multiple payment approaches. <ul style="list-style-type: none"> • prepaid account, post-processing, post-billing and/or stored pre-payment 	Desired



Table 4-1 ATMS Functional Requirements

Technology	Requirement/Feature/Issue	Summary of Agency Response
INTERFACE		
Driver	"Non-distracting" communications to and from driver to assist in: <ul style="list-style-type: none"> • HOV and reversible lane management • Traffic/incident information dissemination • In-vehicle navigation/guidance 	Desired Desired Desired
Traveler	Communications to/from travelers to assist in: <ul style="list-style-type: none"> • Incident management • Traffic information dissemination Provide fare card/smartcard distribution/support.	Desired Desired Desired
Operator	Interface devices and technologies for operator of all ATMS Market Packages Provide operator interface to: <ul style="list-style-type: none"> • monitor account status • assemble/report traffic and revenue statistics • monitor equipment performance 	Desired Desired Desired
CONTROL		
Signals	Signal faces/displays and barriers to effect: <ul style="list-style-type: none"> • Controlling traffic on surface streets and freeways 	Required
Signs	Both in-vehicle signs and side-of-road variable message signs for: <ul style="list-style-type: none"> • Controlling traffic on surface streets and freeways • Traffic information dissemination • Route guidance • Dynamic toll and parking fee management 	Required Required Required Desired



Table 4-2 ATIS Functional Requirements

Technology	Requirement/Feature/Issue	Summary of Agency Response
SENSORS		
Traffic Sensors	Flow data (volumes, occupancies, speeds): <ul style="list-style-type: none"> • Surface street (1-minute, 300' to intersection) • Freeway (1-minute, every 1/2 mile) 	Not Needed Desired
Vehicle Status	Receive Mayday input from vehicle	Desired
Environment	Collect: Weather data (clear, precipitation, wind, fog) Road surface data (ice, snow, rain, dry, chem) Visibility data (fog, snow, clear)	Desired Desired Desired
Security	Screen dynamic rideshare candidates	Not Needed
Location Determination	Obtain traveler trip origin location	Not Needed
COMMUNICATIONS		
Wireless (RF, cellular, etc.)	Between traveler -information service provider for real-time data, map database updates. Transmit Mayday signal to dispatch Obtain trip information for route/mode guidance (origin, destination, departure time)	Not Needed Desired Desired
Broadcast	Congestion, events, etc. to variable message signs/highway advisory radio Updates to in-vehicle map database	Required Desired
Fixed	ATMS to/from information service providers Information service providers to/from travelers <ul style="list-style-type: none"> • current congestion, incidents, events • transit schedule and fare information • carpool/ridesharing request • alternate mode request 	Required Desired Not Needed Not Needed
Algorithms	Dynamic route guidance Dynamic rideshare Determine optimal mode for call-in traveler Dynamic transit routing and scheduling	Not Needed Not Needed Not Needed Not Needed



Table 4-2 ATIS Functional Requirements

Technology	Requirement/Feature/Issue	Summary of Agency Response
Information Management	Traveler information database Freeway and arterial congestion/speed data Transit schedules or link to schedule database Incident database Event status and planned event information Road/weather status and advisories Dynamic rideshare database	Desired Desired Desired Required Desired Desired Not Needed
USER INTERFACES		
Driver Interface	Provide current location Receive current traffic congestion data Receive current incident and event data Transmit rideshare rider pickup information Provide one-touch Mayday / E-911 dispatch	Desired Desired Required Not Needed Desired
Traveler Interface	Provide congestion information, rideshare matching and transit information	Desired
Operator Interface	Provide operator access to traveler information database Provide authorized access to traveler information database Obtain information based on phone request Rideshare Database (name, address, O/D) Current traffic congestion or related data Transit schedules and operation	Desired Desired Desired Not Needed Required Desired



Table 4-3 CVO Functional Requirements

Technology	Requirement/Feature/Issue	Summary of Agency Response
SENSORS		
Vehicle Status	Weigh trucks on freeway network Collect Fuels & Mileage Information	Desired Desired
Cargo Monitoring	Monitor hazardous materials payload	Desired
Loc'n Determin.	For collection of mileage fees	Not Needed
COMMUNICATIONS		
Wireless (RF, cellular, etc.)	Transmit/Receive E-911/Mayday calls Transmit/Receive Fuels & Mileage data Transmit/Receive HAZMAT information Purchase credentials	Required Not Needed Desired Desired
Vehicle-Roadside	Weight/width/height/classification HAZMAT payload Automatic vehicle location Credentials to border personnel	Required Required Desired Required
Fixed	Coordinate NYSDOT and fleet managers Send / receive electronic clearance information	Desired Desired
Algorithms	As needed; weight determination, speed determination, etc.	Desired
Information Management	Manage credentials for border crossings, HAZMAT, oversize vehicles Manage enrollment for electronic clearance Manage incident response to HAZMAT Track HAZMAT shipments Track oversize shipments Collect & Report Fuels & Mileage	Required Desired Required Desired Desired Not Needed
Payment	Allow electronic payment of tolls & fees	Required
INTERFACES		
Driver Interface	Report status of credentials to driver Provide routing information to driver	Desired Desired
Dispatcher/Operator Interface	Purchase credentials Receive fuel & mileage reports Monitor vehicle/freight status/location	Desired Not Needed Desired
CONTROL		
Signals/Signs	Guidance for electronic clearance and WIM	Desired



Table 4-4 EM Functional Requirements

Technology	Requirement/Feature/Issue	Summary of Agency Response
SENSORS		
Traffic Sensors	Detect incident	Required
Environment	Receive pavement/weather sensor data	Desired
Vehicle Status	Receive mayday signal from vehicle sensors	Desired
Security	Receive emergency call box/E-911 calls	Required
Location Determination	Locate a vehicle in need of assistance Locate incident	Required Required
COMMUNICATIONS		
Wireless (RF, cellular, etc)	Receive E-911 calls from drivers Receive Mayday signals Communicate with emergency vehicles Communicate between emergency vehicles and emergency management centers/other transportation providers	Required Required Required Required
Fixed	Provide communications between agencies	Required
Algorithms	Optimal route guidance Incident detection Dynamic vehicle/equipment assignment	Desired Desired Desired
Information Management	Monitor incident status Maintain incident database Maintain emergency vehicle database Maintain optimal route database Maintain vehicle inspection database	Required Required Desired Desired Desired
INTERFACE		
Driver	Provide incident location, characteristics, severity, route guidance	Required
Traveler	Provide capability to communicate with dispatcher	Desired
Operator	Identify type of incident Provide mayday/E-911 dispatch	Required Required
CONTROL		
Signals	Display and receive preemption controls	Required



Table 4-5 ITS Planning Functional Requirements

Technology	Requirement/Feature/Issue	Summary of Agency Response
SENSORS		
Traffic	Allow interchange of detector data between jurisdictions	Desired
COMMUNICATIONS		
Wireless (RF, cellular, etc.)	Transmit/receive: <ul style="list-style-type: none"> • incident response status • electronic clearance data • provide data on HAZMAT cargo • location/status of emergency vehicles 	Required Desired Required Desired
Fixed	Transmit data for electronic clearance Transmit data for electronic payment services	Desired Desired
Information Management	Share resources/responsibility for: <ul style="list-style-type: none"> • Incident/Emergency Vehicle Management • Financial Management • Operations Management Share data for: <ul style="list-style-type: none"> • HAZMAT Incident Response • Electronic Payment Services • Agency Mgmt. & Coordination • Customs/Immigration Inspection & Clearance • CVO Electronic Clearance 	Desired Desired Desired Required Desired Desired Desired Desired
INTERFACES		
Operator Interface	Database interface for <ul style="list-style-type: none"> • Traffic Control • Incident Management/Response 	Required Required



Table 4-6 APTS Functional Requirements

Technology	Requirements/Features/Issues	Summary of Agency Response
SENSORS		
Rail	Detect transit presence for preemption/warning	Required
Environment	Receive pavement/weather sensor data	Desired
Vehicle Monitoring	ID/Monitor: <ul style="list-style-type: none"> • bus/paratransit vehicle location • driver assignment • passenger loading • required maintenance (from vehicle sensor) 	Desired Desired Desired Desired
Driver Monitoring	Monitor driver (condition, shift start/end times)	Desired
Security	Monitor inside transit vehicles Monitor park&ride lots, bus terminals, light rail stations, and platforms Provide emergency call box (panic button or alarm) at various locations	Desired Desired Desired
Location Determination	Track vehicle location (automatic vehicle location (AVL) system)	Desired
COMMUNICATIONS		
Wireless (RF, cellular, etc.)	Between drivers and dispatcher Between drivers Between drivers and E-911	Required Desired Required
Vehicle-Roadside	Collect transit vehicle and driver ID Collect transit loading data	Desired Desired
Broadcast	Broadcast emergency information to passengers Broadcast the schedule and/or the route changes to passengers	Desired Desired
Fixed	Communicate between: <ul style="list-style-type: none"> • traveler and information personnel • transit dispatch and information personnel • transit dispatch and E-911 • stations and E-911 • transit management center and traffic management center to arrange for signal priority 	Desired Desired Required Required Desired



Table 4-6 APTS Functional Requirements

Technology	Requirements/Features/Issues	Summary of Agency Response
Algorithms	Provide multimodal coordination Estimate arrival times Dynamic scheduling/routing Vehicle and driver assignment Automatic maintenance scheduling and monitoring Others as needed	Desired Desired Desired Desired Desired
Payment	Accept electronic payment (smart card, magnetic strip card, ATM) Input data to fare collection database (by vehicle, route, day, time, season)	Desired Desired
Information Management	Create and maintain: <ul style="list-style-type: none"> • fare payment database • driver database • passenger flow database • transit and paratransit route database • vehicle inspection database, etc. 	Desired Desired Desired Desired Desired
INTERFACE		
Driver	ID current location ID driver status (layover, break, etc.) Traffic, pavement, weather condition Passenger pick up Maintenance information Mayday/E-911 dispatch	Desired Desired Desired Desired Desired Required
Traveler	Provide broadcast of emergency messages and dynamic changes in schedule and/or route Provide schedule information Provide in-vehicle park & ride information	Desired Desired Desired
Operator	Provide operator access to schedule, driver, vehicle, route, customer database to obtain and modify information	Desired
CONTROL		
Signals	Receive pre-emption signal from transit vehicles	Desired



Table 4-7 AVSS Functional Requirements

Technology	Requirement/Feature/Issue
SENSORS	
Vehicle Status	Monitor the roadway and intersection infrastructure to assess the vehicle location and speed near intersection Monitor in-vehicle sensors to determine collision probability and deploy a pre-crash or crash consequences mitigation safety system
Environment	Receive information about pavement condition Receive information about weather condition
Vehicle Monitoring	Receive information from on-board sensors about vehicle conditions and performance and display the information Receive information from on-board sensor about the area around vehicle and present warning to the driver Receive information from on-board sensor about the longitudinal gaps and vehicle speed to control headway and vehicle speed Receive information from on-board sensor about the lane position and lateral deviation to monitor steering
Obstacle Ranging	Receive information from collision sensors to determine the probability of collision (proximity detection sensors)
Driver Monitoring	Receive information from on-board sensors to monitor driver condition Provide warning
COMMUNICATIONS	
Vehicle - Roadside	Communicate a control action to a vehicle for collision avoidance
Algorithms	Determine a vehicle condition based on in-vehicle sensor data and produce warning information Determine a driver condition based on in-vehicle sensor data and produce warning information Determine control measures and warning information based on roadside sensor data



Table 4-7 AVSS Functional Requirements

Technology	Requirement/Feature/Issue
INTERFACE	
Driver	Provide warning about vehicle condition and warn the driver about potential danger Provide warning about driver condition Provide warning about hazardous condition at intersection Provide pre-crash warning
CONTROL	
Vehicles	Deploy a pre-crash or crash consequence mitigation systems Control vehicle speed Control vehicle steering