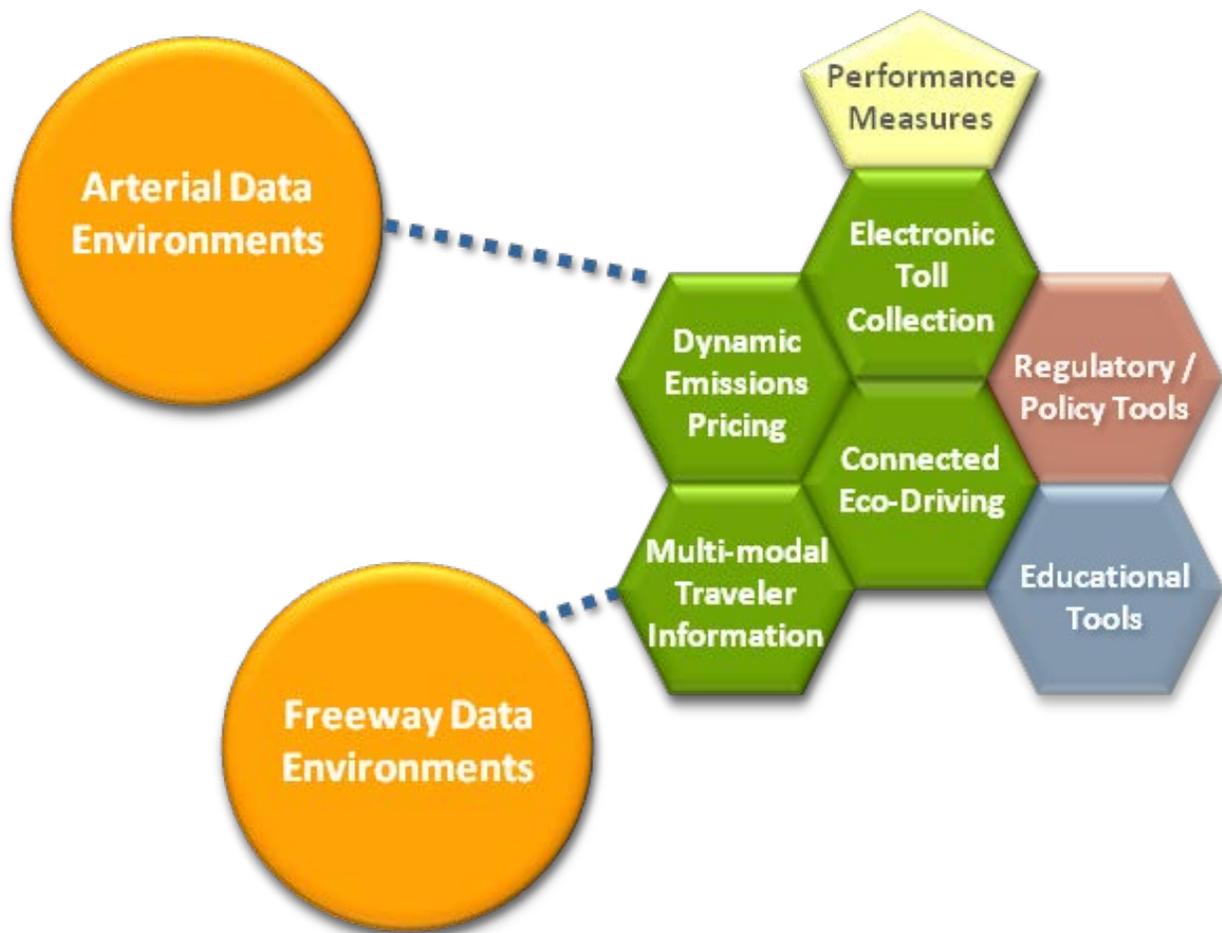




AERIS TRANSFORMATIVE CONCEPTS

"Cleaner Air Through Smarter Transportation"



Dynamic Low Emissions Zones

AERIS User Needs Workshop: March 14th-15th, 2012

Read-Ahead Packet

1 BACKGROUND

1.1 The AERIS Program

The Intelligent Transportation Systems (ITS) Joint Program Office (JPO) is charged with the planning and execution of the ITS Program as authorized by Congress. The ITS JPO is part of the Research and Innovative Technology Administration (RITA) of the U.S. Department of Transportation (USDOT). This program encompasses a broad range of technologies that are applied to the surface transportation system. Under collaborative and transparent governance structure established for ITS JPO projects, the ITS JPO coordinates with and executes the program jointly in cooperation with all of the surface transportation modal administrations within the DOT to ensure full coordination of activities and leveraging of research efforts.

The USDOT is engaged in assessing applications that realize the full potential of connected vehicles, travelers and infrastructure to enhance current operational practices and transform future surface transportation systems management. This effort is a collaborative initiative spanning the Intelligent Transportation Systems Joint Program Office (ITS JPO), Federal Highway Administration (FHWA), the Federal Transit Administration (FTA), the Federal Motor Carrier Safety Administration (FMCSA) and the National Highway Traffic Safety Administration (NHTSA). These agencies of the Federal Government work closely with the American Association of State Highway and Transportation Officials (AASHTO), who represent state transportation agencies across the country, as well as the numerous private sector interests (car manufacturers, technology companies, etc.) in working together in developing a nationwide system for ITS to be deployed in the future.

One foundational element of the ITS research efforts is the environment research area. The vision and objectives of the AERIS Program include:

VISION: *Cleaner Air Through Smarter Transportation*

OBJECTIVES: Investigate whether it possible and feasible to:

- Generate/capture environmentally-relevant real-time transportation data (from vehicles and the system)
- Use this environmental data to create actionable information that can be used by system users and operators to support and facilitate “green” transportation choices for all modes
- Assess whether doing these things yields a good enough environmental benefit to justify further investment by the USDOT

The AERIS Program recently concluded the first phase of their activity focused on foundational research and has moved into the second phase focused on Concept of Operations (ConOps) development, cost-benefit analysis, and modeling a portfolio of innovative environmental applications called Transformative Concepts.

1.2 What is a Transformative Concept?

Transformative Concepts are integrated, operational strategies that use vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) data and communications to operate surface transportation networks and to help travelers make “green” travel choices with the aim of reducing the environmental impacts of transportation-related emissions and fuel consumption. Transformative Concepts consist of applications or technological solutions designed to ingest, process, and disseminate data in order to address a specific task. Transformative Concepts

emphasize combining applications that result in significant environmental benefits to surface transportation networks. Transformative Concepts also consider regulatory/policy and educational tools. The six (6) AERIS Transformative Concepts are:

- Eco-Signal Operations
- Eco-Lanes
- Dynamic Low Emissions Zones
- Support for Alternative Fuel Vehicle (AFV) Operations
- Eco-Traveler Information
- Eco-Integrated Corridor Management (ICM)

2 AERIS WORKSHOP BREAK-OUT SESSIONS

As the AERIS Workshop is intended to engage the community, participants should leave the workshop with a greater understanding of the AERIS Program and the AERIS Transformative Concepts. Additionally, each participant should feel that they have contributed to the development of the AERIS Transformative Concepts.

On the second day of the workshop, workshop participants will participate in Break-out Sessions for three of the AERIS Transformative Concepts: (1) Eco-Signal Operations, (2) Eco-Lanes, and (3) Dynamic Low Emissions Zones. The purpose of these break-out sessions is to elicit user needs for Concepts of Operations that will be developed for the Transformative Concepts. These Concepts of Operations will provide a blueprint that helps the AERIS Team and other stakeholders understand the various moving parts of the Transformative Concepts.

During the Break-out Sessions, a facilitator will be walking the workshop participants through a storyboard describing the AERIS Transformative Concept. At each step of the storyboard a facilitated discussion will take place around the following questions:

Break-out Session Questions

- (1) Who are the actors for each of the AERIS Transformative Concepts?
- (2) What applications are the actors responsible for?
- (3) What are the interactions between actors at each step of the Transformative Concept?
- (4) What type of information is exchanged between actors at each step of the Transformative Concept?

The following sections of this Read-Ahead Packet provide detailed information for the Transformative Concept, including the following information:

- Description of the AERIS Transformative Concept (Section 3.1)
- List and description of the applications that pertain to the AERIS Transformative Concept (Section 3.2)
- Actors that pertain to the AERIS Transformative Concept (Section 3.3)
- Communications Diagram (Section 3.4)
- Strawman Information Flow Diagram (Section 3.5)

3 DYNAMIC LOW EMISSIONS ZONES

3.1 Description

This Transformative Concept includes a geographically defined area (i.e., cordon) which seeks to restrict or deter access by specific categories of high-polluting vehicles within the zone, for the purpose of improving the air quality within the geographic area. Connected vehicle technology would be leveraged to dynamically determine fees for vehicles entering the low emissions zone. The fee for entering the low emissions zone could be based on the vehicle's engine emissions standard or historical emissions data collected directly from the vehicle using V2I communications; the driving patterns exhibited by the driver; and by air quality predictions for the zone.

This Transformative Concept also provides the capability for dynamic low emissions zones. Using connected vehicle technologies, low emissions zone applications allow for geo-fencing of the cordon. This allows the low emissions zone to be dynamic, popping up based on various criteria including atmospheric conditions, weather conditions, or special events.

This Transformative Concept would also encourage eco-driving inside the low emissions zone. Once inside the low emissions zone, if real-time data from the vehicle shows that it is being driven in a manner that reduces emissions (i.e., practicing eco-driving tactics), the driver could be given an economic reward. Connected eco-driving—embedded in all of the Transformative Concept—may also be implemented within the low emissions zone to encourage eco-driving tactics. Transit vehicles would be able to enter the low emissions zone without paying a fee, encouraging commuters to use public transportation.

3.2 Applications

Applications are technological solutions designed to ingest, process, and disseminate data in order to address a specific task. The Dynamic Low Emissions Zones Transformative Concept is composed of the following applications:

- **Connected Eco-Driving** | This application provides individual drivers (i.e., personal vehicles, transit, freight) with eco-driving information with the objective of promoting a driving style that lowers vehicle emissions. The Application provides drivers with real-time information (i.e., recommended speeds, accelerations) based on signal phase and timing of upcoming intersections, traffic, and road weather conditions so they can make decisions about their driving behavior. The Application also provides feedback to drivers on their driving behavior to encourage drivers to drive in a more environmentally efficient manner. The Connected Eco-Driving Application may also have vehicle systems implement the eco-driving tactics (i.e., change gears, switch power sources, or reduce speed in an eco-friendly manner as the vehicle approaches a traffic signal).
- **Dynamic Emissions Pricing** | This application determines fees and incentives using data collected from vehicles and the environment. This data may include the vehicle class, real-time emissions data, driving behavior (e.g., excessive speeding or eco-driving behavior within a Low-Emissions Zone), road weather conditions, traffic, and other data associated with emissions. Where geo-fencing is enabled, the Application adjusts boundaries of the tolled area (e.g., segment of road, Low-Emissions Zone) based on various criteria including road weather conditions, traffic, special events.

- Electronic Toll Collection (ETC) | This application supports payments of tolls by electronically debiting the accounts of registered vehicle owners without requiring vehicles to stop. These applications use connected vehicle technologies instead of conventional toll tags for the payment of tolls. Additionally, these applications provide drivers with messages for toll prices prior to entering the tolled facility.
- Multi-Modal Traveler Information | This application conveys pre-trip and en-route multi-modal traveler information to encourage environmentally friendly transportation choices such as taking transit, change in time of travel or destination as appropriate. The information will be generated using connected vehicle data from all vehicle classes including automobiles and transit. Using travel conditions, information will be provided on expected vehicle delays, transit delays, detailed transit schedule, and expected arrival of trains/buses. The Application will demonstrate if there is a public sector role in providing traveler information, such as data collection and dissemination.

3.3 Actors

For a Transformative Concept to operate, interactions need to take place between actors. Actors represent roles played by human users, external hardware or software, a center, or a vehicle. For the purpose of this workshop, actors do not necessarily represent a specific physical entity, but merely a particular facet (i.e., “role”) of some entity that is relevant to the specification of its associated use cases. Additionally, a single physical entity (i.e., a traffic management center) may play the role of several different actors and, conversely, a given actor may be played by multiple different instances. For example, a traffic management center may play the traffic management and toll administration roles. While it plays multiple roles, the traffic management center is a single physical entity. Conversely, there is likely more than one traffic management center in a region or a state.

Descriptions of the actors specific to the Dynamic Low Emissions Zones Transformative Concept are provided below. These descriptions were taken from the National ITS Architecture. Actors are categorized into four areas: (1) centers, (2) vehicles, (3) travelers, and (4) roadside.

Centers

- Traffic Management | The Traffic Management actor monitors and controls traffic and the road network, including the *control of traffic signals*. It represents centers that manage a broad range of transportation facilities including freeway systems, rural and suburban highway systems, and urban and suburban traffic control systems. This actor communicates with the Roadway actor to monitor and manage traffic flow and monitor the condition of the roadway, surrounding environmental conditions, and field equipment status (e.g., traffic signals). This actor coordinates with the Maintenance and Construction Management actor to maintain the road network and coordinate and adapt to maintenance activities, closures, and detours. Incidents are detected, verified, and incident information is provided to allied agencies, drivers (through Roadway actor highway advisory radio and dynamic message signs), and information service providers. This actor also manages traffic and transportation resources to support allied agencies in responding to, and recovering from, incidents ranging from minor traffic incidents through major disasters. The Traffic Management actor supports high occupancy vehicle (HOV) lane management and coordination, road pricing, and other demand management policies that can alleviate congestion and influence mode selection. The actor communicates with other Traffic Management actors to coordinate traffic information and control strategies in neighboring jurisdictions.
- Emissions Management | The Emissions Management actor provides the capabilities for air quality managers to monitor and manage air quality. These capabilities include collecting emissions data from distributed emissions sensors within the Roadway actor, from Vehicle actors, and ingesting regional air quality data from external sources and sensors such as operated by the National Weather Service or the Environmental Protection Agency. These sensors monitor general air quality within each sector of the area and also monitor the emissions of individual vehicles on the roadway. The sector emissions measures are collected, processed, and used to identify sectors exceeding safe pollution levels. This information is provided to traffic management to implement strategies intended to reduce emissions in and around the problem areas. Emissions data associated with individual vehicles, supplied by the Roadway and Traffic Management actors, are also processed and monitored to identify vehicles that exceed standards. This actor provides any functions necessary to inform the violators and otherwise ensure timely compliance with

emissions standards. This actor may co-reside with the Traffic Management actor or may operate in its own distinct location depending on regional preferences and priorities.

- Toll Administration | The Toll Administration Actor provides general toll administration capabilities and supports the electronic transfer of authenticated funds from the customer to the transportation system operator or other service provider. Charges can be recorded for tolls, vehicle-mileage charging, congestion charging, or other goods and services. This actor supports traveler enrollment and collection of both pre-payment and post-payment transportation fees in coordination with the existing, and evolving financial infrastructure supporting electronic payment transactions. The system may establish and administer escrow accounts depending on the clearinghouse scheme and the type of payments involved. This actor posts a transaction to the customer account and generates a bill (for post-payment accounts), debits an escrow account, or interfaces to the financial infrastructure to debit a customer designated account. It supports communications with the Connected Vehicle Roadside Equipment Actor to support fee collection operations. As an alternative, a wide-area wireless interface can be used to communicate directly with vehicle equipment. The actor also sets and administers the pricing structures and includes the capability to implement road pricing policies in coordination with the Traffic Management Actor. The electronic financial transactions in which this actor is an intermediary between the customer and the financial infrastructure shall be cryptographically protected and authenticated to preserve privacy and ensure authenticity and auditability.
- Other Region Centers | The other region centers actor represents other regional centers. It is intended to provide a source and destination for ITS information flows between peer (e.g. inter-regional) center functions. It enables traffic and transit management activities to be coordinated across different jurisdictional areas.

Vehicles

- Personal Vehicle | The Vehicle actor provides the sensory, processing, storage, and communications functions necessary to support efficient, safe, and environmentally efficient travel. Information services provide the driver with current travel conditions and the availability of services along the route and at the destination. Both one-way and two-way communications options, including 5.9 Gigahertz (GHz) band approved for DSRC use by the Federal Communications Commission (FCC), support a spectrum of information services. Route guidance capabilities assist in formulation of an optimal route and step by step guidance along the travel route. Advanced sensors, processors, enhanced driver interfaces, and actuators complement the driver information services so that, in addition to making informed mode and route selections, the driver travels these routes in a safer and more consistent manner. Initial collision avoidance functions provide 'vigilant co-pilot' driver warning capabilities. More advanced functions assume limited control of the vehicle to maintain safe headway. Ultimately, this actor supports completely automated vehicle operation through advanced communications with other vehicles in the vicinity and in coordination with supporting infrastructure actors. Pre-crash safety systems are deployed and emergency notification messages are issued when unavoidable collisions do occur.

- Commercial Vehicle | The Commercial Vehicle actor resides in a commercial vehicle and provides the sensory, processing, storage, and communications functions necessary to support efficient, safe, and environmentally efficient travel. Information services provide the driver with current travel conditions and the availability of services along the route and at the destination. Both one-way and two-way communications options, including 5.9 Gigahertz (GHz) band approved for DSRC use by the Federal Communications Commission (FCC), support a spectrum of information services. Route guidance capabilities assist in formulation of an optimal route and step by step guidance along the travel route. Advanced sensors, processors, enhanced driver interfaces, and actuators complement the driver information services so that, in addition to making informed mode and route selections, the driver travels these routes in a safer and more consistent manner. Initial collision avoidance functions provide 'vigilant co-pilot' driver warning capabilities. More advanced functions assume limited control of the vehicle to maintain safe headway. Ultimately, this actor supports completely automated vehicle operation through advanced communications with other vehicles in the vicinity and in coordination with supporting infrastructure actors. Pre-crash safety systems are deployed and emergency notification messages are issued when unavoidable collisions do occur.

The Commercial Vehicle actor also provides two-way communications between the commercial vehicle drivers, their fleet managers, attached freight equipment, and roadside officials, and provides HAZMAT response teams with timely and accurate cargo contents information after a vehicle incident. This actor provides the capability to collect and process vehicle, cargo information from the attached freight equipment, and driver safety data and status and alert the driver whenever there is a potential safety or security problem. Basic identification, security and safety status data are supplied to inspection facilities and roadside infrastructure at mainline speeds. In addition, the actor will automatically collect and record emissions, environmental data, mileage, fuel usage, and border crossings.

- Transit Vehicle | The Transit Vehicle actor resides in a transit vehicle and provides the sensory, processing, storage, and communications functions necessary to support efficient, safe, and environmentally efficient travel. Information services provide the driver with current travel conditions and the availability of services along the route and at the destination. The types of transit vehicles containing this actor include buses, paratransit vehicles, light rail vehicles, other vehicles designed to carry passengers, and supervisory vehicles. Both one-way and two-way communications options, including 5.9 Gigahertz (GHz) band approved for DSRC use by the Federal Communications Commission (FCC), support a spectrum of information services. Route guidance capabilities assist in formulation of an optimal route and step by step guidance along the travel route. Advanced sensors, processors, enhanced driver interfaces, and actuators complement the driver information services so that, in addition to making informed mode and route selections, the driver travels these routes in a safer and more consistent manner. Initial collision avoidance functions provide 'vigilant co-pilot' driver warning capabilities. More advanced functions assume limited control of the vehicle to maintain safe headway. Ultimately, this actor supports completely automated vehicle operation through advanced communications with other vehicles in the vicinity and in coordination with supporting infrastructure actors. Pre-crash safety systems are deployed and emergency notification messages are issued when unavoidable collisions do occur.

The Transit Vehicle actor also supports a traffic signal prioritization function that communicates with the roadside actor to improve on-schedule performance. Automated vehicle location functions enhance the information available to the Transit Management actor enabling more efficient operations.

Roadside

- **Connected Vehicle Roadside Equipment** | The Connected Vehicle Roadside Equipment actor includes the roadside equipment (RSE) units distributed on and along the roadway. These devices are capable of both transmitting and receiving data using dedicated short range communications (DSRC) radios, using the 5.9 Gigahertz (GHz) band approved for DSRC use by the Federal Communications Commission (FCC). The devices also support other wireless communications, such as cellular and Wi-Fi communications. RSE units support the appropriate Institute of Electrical and Electronics Engineers (IEEE) and Society of Automotive Engineers (SAE) standards (IEEE 802.11p, IEEE 1609 family, and SAE J2735). The Connected Vehicle Roadside Equipment actor also includes local processing capabilities to support processing of data at the roadside.
- **Roadside Charging Infrastructure** | The Roadside Charging Infrastructure Actor includes roadside infrastructure deployed along the roadway that uses magnetic fields to wirelessly transmit large electric currents between metal coils placed several feet apart. This infrastructure enables inductive charging of electric vehicles including cars, trucks, and buses. Roadside Charging Infrastructure supports static charging capable of transferring electric power to a vehicle parked in a garage or on the street and vehicles stopped at a traffic light. It also supports charging vehicles moving at highway speeds.

Travelers

- **Personal Information Access** | The Personal Information Access Actor provides the capability for travelers to receive formatted traffic advisories from their homes, place of work, major trip generation sites, personal portable devices, over multiple types of electronic media. These capabilities also provide basic routing information and allow users to select those transportation modes that allow them to avoid congestion, or more advanced capabilities to allow users to specify those transportation parameters that are unique to their individual needs and receive travel information. This actor provides travelers with the capability to receive route planning from the infrastructure at fixed locations such as in their homes, their place of work, and at mobile locations using personal portable devices and vehicle-based devices. In addition to end user devices, this actor may also represent a device that is used by a merchant or other service provider to receive traveler information and relay important information to their customers. This actor also provides the capability to initiate a distress signal and cancel a prior-issued manual request for help.

3.4 Communications Interconnect Diagram

Figure 1 shows the various actors and the interactions between them. This diagram has been adapted from the National ITS Architecture and categorizes actors into four categories: (1) centers, (2) travelers, (3) vehicles and (4) roadside. The pink rectangles in the diagram describe communications technologies and how these actors connected. These communication technologies include:

- Wide area wireless communications
- Fixed point to fixed point communications
- Vehicle-to-vehicle (V2V) communications
- Infrastructure-to-vehicle (I2V) and vehicle-to-infrastructure (V2I) communications

Figure 1 has been adapted for the Dynamic Low Emissions Zones Transformative Concept. Actors and interconnects that are not relevant to the Transformative Concept have been 'grayed out'.

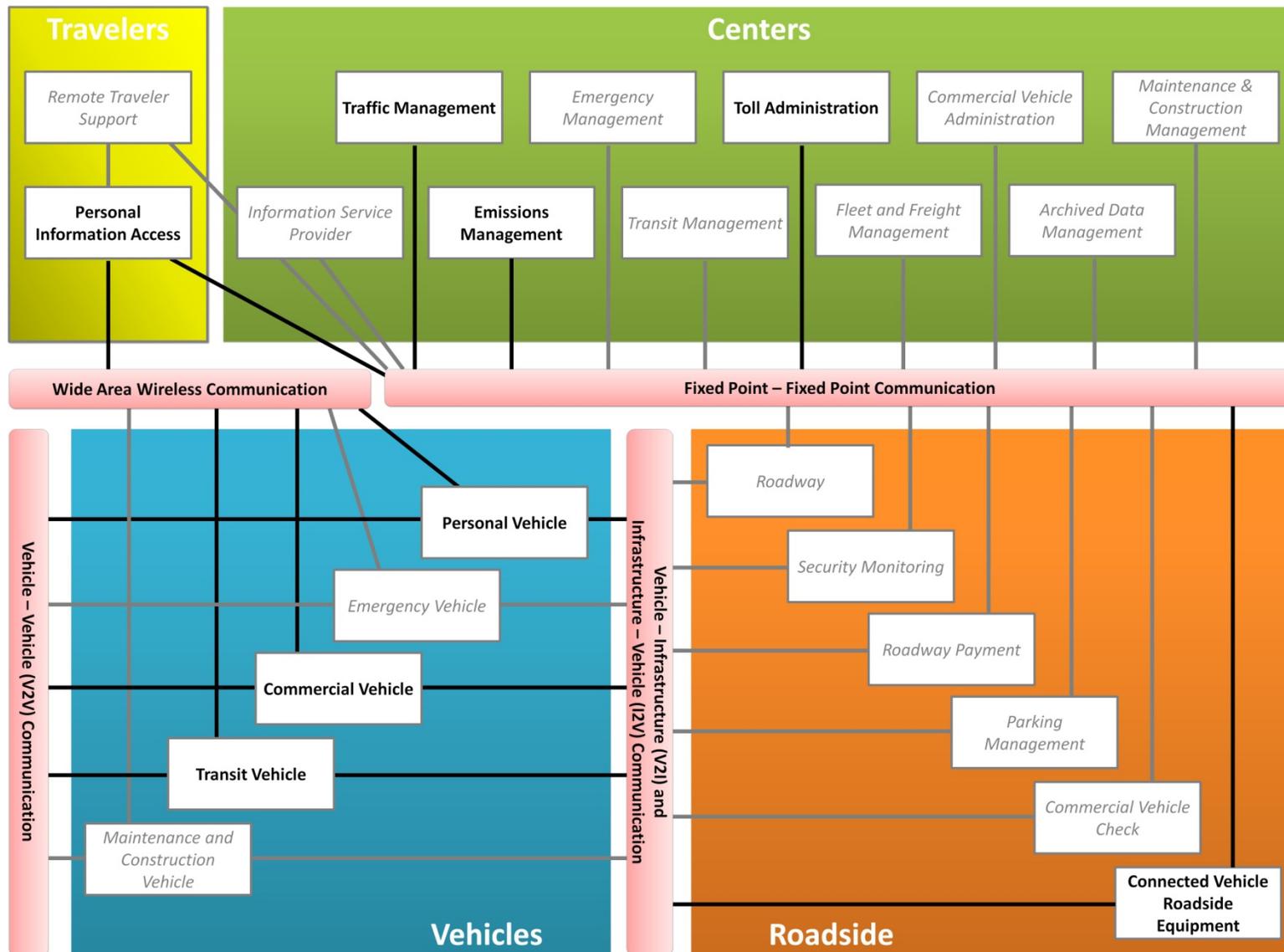


Figure 1 – Dynamic Low Emissions Zones Communications Interconnect Diagram

3.5 Strawman Information Flow Diagram

Information flow diagrams provide a graphical representation of the "flow" of information for a Transformative Concept for multiple applications at the same time. The information flow diagram depicts what kinds of information will be input and output from each actor, where the data will come from and go to, and where the data will be stored. It does not show information about the timing of processes, or information about whether processes will operate in sequence or in parallel (which is shown on a flowchart). In summary, the information flow diagrams show:

- The actors and interactions between actors for the Transformative Concepts
- The type of information that needs to be exchanged between actors to enable environmental applications and AERIS Transformative Concepts

Figure 2 depicts an example of an information flow being exchanged between actors. In this example, the actors are depicted using the green and orange boxes. The colors of these boxes correspond to the color coding in the Communication Interconnect Diagram. The gray boxes represent applications operated by that actor. In the example below, the 'traffic management' actor is controlling a traffic signal. This is denoted by the information flow labeled 'traffic signal control'. In return the traffic signal, or 'roadway' actor, provides traffic data (i.e., speed and volume data) back to the 'traffic management' actor.

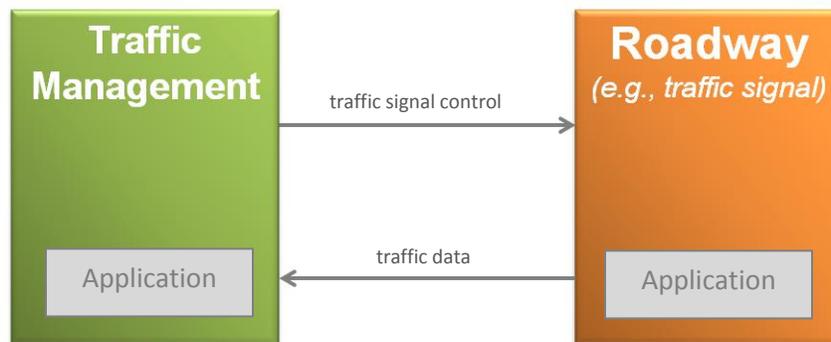


Figure 2 – Example Information Flow

Figure 3 depicts a *strawman* information flow diagram for the Dynamic Low Emissions Zones Transformative Concept. The actors are color-coded according to the categories in the Communications Interconnect Diagram. 'Travelers' are shown in yellow boxes, 'centers' in green boxes, 'vehicles' in blue boxes, and 'roadside' in orange boxes. Applications are shown within the actors in smaller gray boxes. Descriptions of these applications are provided in section 2.2. Arrows between actors depict information flows.

The purpose of the AERIS Transformative Concepts User Needs Workshop is to use these diagrams to begin thinking about the Transformative Concepts in more detail and to identify/verify:

- The actors as they pertain to the AERIS Transformative Concepts
- The applications for which that actor is responsible
- The interactions between actors at each step of the AERIS Transformative Concept
- The type of information exchanged between actors

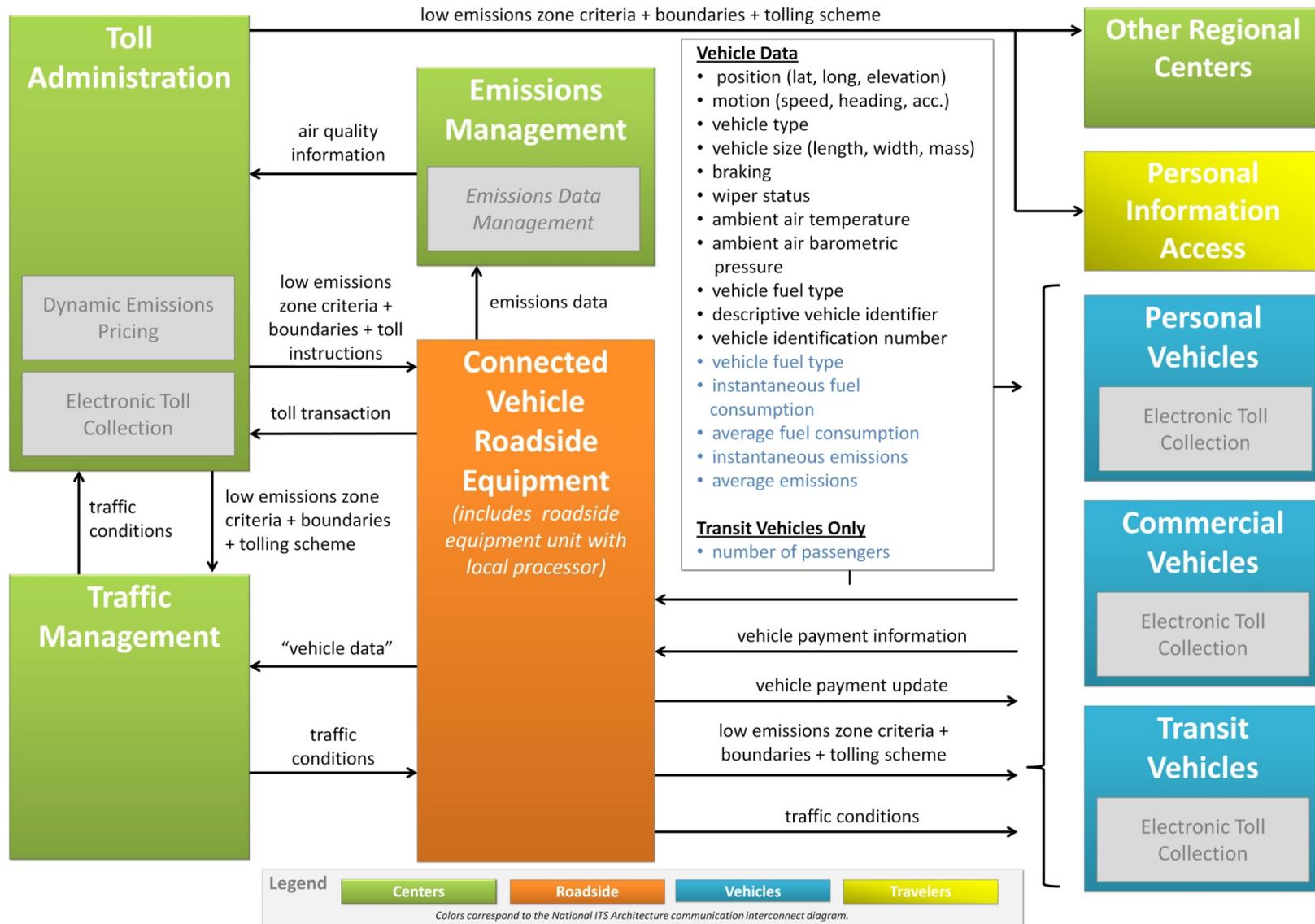


Figure 3 – Dynamic Low Emissions Zones Information Flow Diagram