AERIS Transformative Concepts and Applications Descriptions

The Applications for the Environment: Real-Time Information Synthesis (AERIS) Program identified six Transformative Concepts or bundles of applications, including: (1) Eco-Signal Operations, (2) Dynamic Eco-Lanes, (3) Dynamic Low Emissions Zones, (4) Eco-Traveler Information, (5) Support for Alternative Fuel Vehicle Operations, and (6) Eco-Integrated Corridor Management. Each Transformative Concept encompasses a set of applications which individually achieve environmental benefits. By strategically bundling these applications, the AERIS Program expects that Transformative Concepts can achieve additional environment benefits above those of the individual applications.

As shown in Figure 1, each Transformative Concept is comprised of applications (depicted as green hexagons), regulatory/policy tools (depicted as red hexagons), educational tools (depicted as blue hexagons) and performance measures (depicted as yellow pentagons). Applications are technological solutions (e.g., software, hardware, interfaces) designed to ingest, process, and disseminate data in order to address a specific strategy. For example, the eco-traffic signal priority application may collect data from vehicles, sends these data to a local processor to determine if a vehicle should be granted priority at a signalized intersection, and then communicate this priority request to a traffic signal controller.

Applications are complemented with regulatory/policy and educational tools to further support the Transformative Concept. Regulatory/policy tools are authoritative rules that govern transportation, land development, and/or environmental behavior. For example, a Dynamic Low Emissions Zone would require policy to be in place for the geographic area before a low emissions zone could be commissioned. This policy may establish the guidelines or rules that would be in place governing the low emissions system.

Since many of the AERIS Transformative Concepts and applications are new ideas that the traveling public may not be familiar with, there is a need for educational tools or campaigns used for of educating transportation agencies and/or the general public on environmental benefits of the applications or Transformative Concepts. Finally, each Transformative Concept includes performance measures which are used for collecting and reporting information regarding the performance of the Transformative Concept. These performance measures include goals and objectives for reducing emissions, improving traffic flow, and improving transportation or environmental performance.

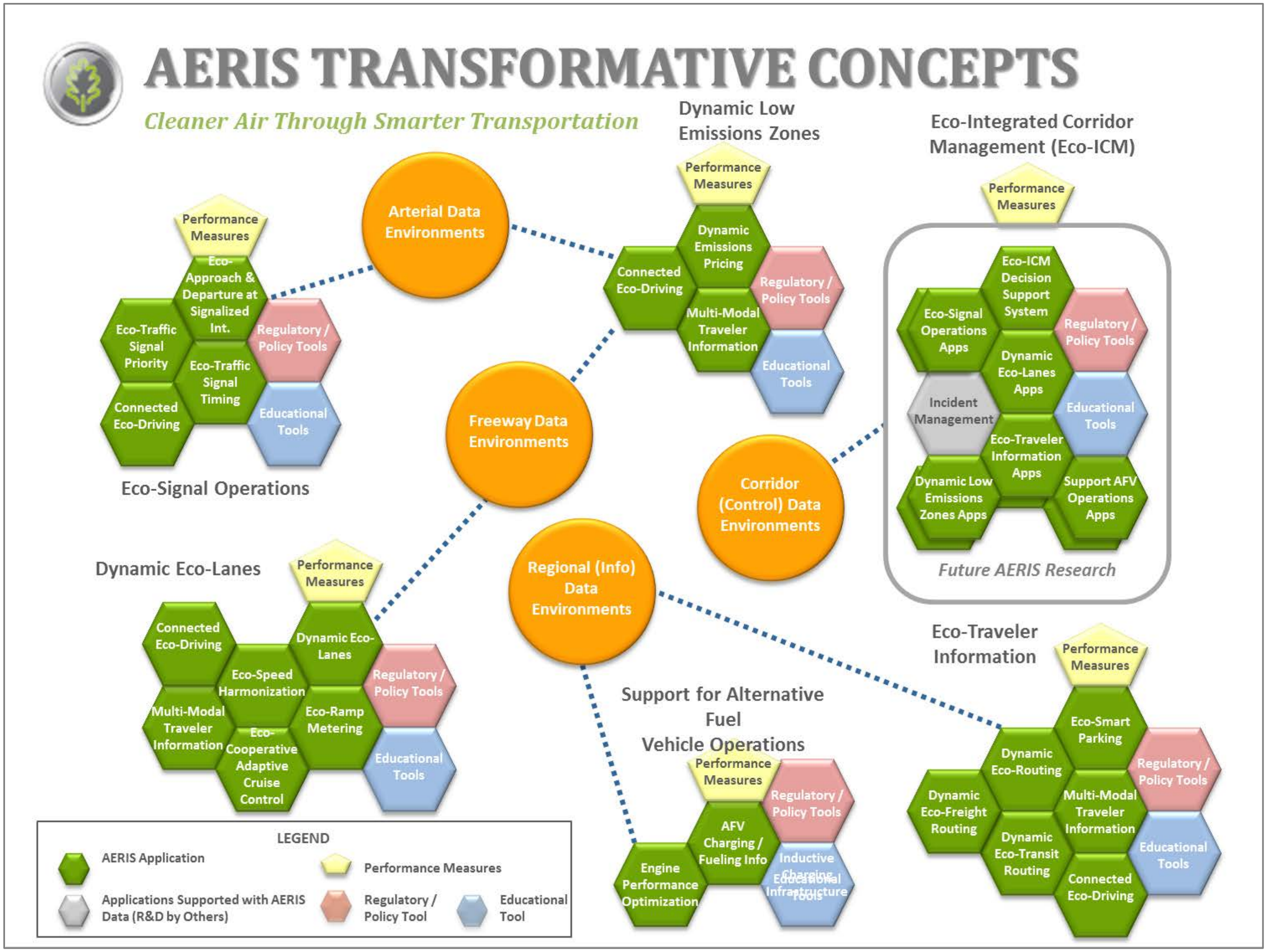

Figure 1. AERIS Transformative Concepts and Applications

Each Transformative Concept is connected to one or more Data Environment – or orange circle. Data Environments are well-organized collection of data, of specific type and quality that are captured and stored at regular intervals from one or more sources, and systematically shared in support of one or more applications. These Data Environments are defined by the USDOT's Data Capture and Management (DCM) Program. A description of each Data Environment is provided below:

- **Arterial Data Environment |** The Arterial Data Environment organizes multi-source data along a signalized arterial facility. Vehicles in this environment may include personal, transit, freight, non-motorized, emergency, and construction/maintenance vehicles. Data could be collected from all of these vehicles as well as mobile devices and roadside infrastructure. It is assumed that the Arterial Data Environment would be a signal arterial facility, bi-directional in nature. All data would be captured as vehicles approach and leave intersections along the arterial. Bus-only lanes, bike lanes, and pedestrian crosswalks may be present in the environment. Travel demand is expected to be highly variable based on time of day and day of week.

- **Freeway Data Environment |** The Freeway Data Environment organizes multi-source data along an uninterrupted flow (freeway) facility. Vehicles in this environment may include personal, transit, freight, non-motorized, emergency, and construction/maintenance vehicles. Data could be collected from all of these vehicles as well as mobile devices and roadside infrastructure. It is assumed that the Freeway Data Environment would be a freeway facility, bi-directional in nature. All data would be captured along the freeway lanes and the interchanges including the ramps and arterial segments providing ramp access. Freeway lanes may have varying restrictions such as HOV or bus only lanes. Tolling may also be present in the freeway environment. Travel demand is expected to be highly variable based on time of day and day of week.

- **Corridor Data Environment |** The Corridor Data Environment organizes multi-source in a multi-modal sub-regional corridor. Vehicles in this environment may include personal, transit, freight, non-motorized, emergency, and construction/maintenance vehicles. Data could be collected from all of these vehicles as well as mobile devices and roadside infrastructure. It is assumed that the Corridor Data Environment would primarily carry direction travel demand (inbound or outbound) depending on the time of day and day of the week. Parallel arterial and freeway facilities as well as transit facilities would all be included in this environment. All data from all the types of facilities within the corridor would be collected into the Corridor Data Environment. These data environment would help support things such as Integrated Corridor Management (ICM).

- **Regional Data Environment |** The Regional Data Environment organizes multi-source in a regional, state-wide, rural, multi-state or national data environment. Vehicles in this environment may include personal, transit, freight, non-motorized, emergency, and construction/maintenance vehicles. Data could be collected from all of these vehicles as well as mobile devices and roadside infrastructure. It is assumed that the Regional Data Environment would span a network of subsidiary sub-networks including arterial, freeway, rural, parking, and transit facilities. The regional network carries significant traveler demand and supports critical goods movement between intermodal facilities.

The AERIS Transformative Concepts and Applications are provided below. Descriptions of each Transformative Concept and Application are included in the following sections.

Eco-Signal Operations

1. Eco-Approach and Departure at a Signalized Intersections
2. Eco-Traffic Signal Timing
3. Eco-Transit Signal Priority
4. Eco-Freight Signal Priority
5. Connected Eco-Driving

Dynamic Eco-Lanes

1. Dynamic Eco-Lanes
2. Eco-Speed Harmonization
3. Eco-Cooperative Adaptive Cruise Control
4. Eco-Ramp Metering
5. Connected Eco-Driving
6. Multi-Modal Traveler Information

Dynamic Low Emissions Zones

1. Dynamic Emissions Pricing
2. Connected Eco-Driving
3. Multi-Modal Traveler Information

Support for Alternative Fuel Vehicle Operations

1. Engine Performance Optimization
2. AFV Charging / Fueling

Eco-Traveler Information

1. Dynamic Eco-Routing
2. Dynamic Eco-Transit Routing
3. Dynamic Eco-Freight Routing
4. Eco-Smart Parking
5. Connected Eco-Driving
6. Multi-Modal Traveler Information

Eco-Integrated Corridor Management (Eco-ICM)

1. Eco-Integrated Corridor Management Decision Support System

** Applications from the Other Transformative Concepts

ECO-SIGNAL OPERATIONS TRANSFORMATIVE CONCEPT

The Eco-Signal Operations Transformative Concept uses connected vehicle technologies to decrease fuel consumption and decrease GHG and criteria air pollutant emissions by reducing idling, the number of stops, unnecessary accelerations and decelerations as well as improving traffic flow at signalized intersections. The Eco-Signal Operations Transformative Concept features four applications:

- Eco-Approach and Departure at Signalized Intersections
- Eco-Traffic Signal Timing
- Eco-Traffic Signal Priority
- Connected Eco-Driving

A foundational component of this concept uses wireless data communications among enabled vehicles and roadside infrastructure. This includes broadcasting signal phase and timing (SPaT) data to vehicles. Upon receiving this information, the Eco-Approach and Departure at Signalized Intersections application performs calculations to provide speed advice to the driver of the vehicle, allowing the driver to adapt the vehicle's speed to pass the next signal on green or to decelerate to a stop in the most eco-friendly manner. This application also considers a vehicle's acceleration as it departs from a signalized intersection.

This Transformative Concept also considers Eco-Traffic Signal Timing applications. These applications are similar to current adaptive traffic signal systems; however the application's objective would be to optimize traffic signals for the environment using connected vehicle data. These applications collect data from vehicles, such as vehicle location, speed, GHG and other emissions data using connected vehicle technologies to determine the optimal operation of the traffic signal system based on the data.

Eco-Traffic Signal Priority applications are also included as part of this Transformative Concept. These applications allow either transit or freight vehicles approaching a signalized intersection to request signal priority. These applications consider the vehicle's location, speed, vehicle type (e.g., Alternative Fuel Vehicles) and associated GHG and other emissions to determine if priority should be granted. Other information, such as a transit vehicle's adherence to its schedule or number of passenger, may also be considered in granting priority.

Finally, Connected Eco-Driving Applications provide customized real-time driving advice to drivers so that they can adjust their driving behavior to save fuel and reduce emissions while driving on arterials. This advice includes recommended driving speeds, optimal acceleration, and optimal decelerations profiles based on prevailing traffic conditions and interactions with nearby vehicles. This application would also help optimize vehicle trajectories at non-signalized intersections such as stop signs and yield signs.

Table 1. Eco-Signal Operations Applications

No.	Application	Description
1	**Eco-Approach and Departure at a Signalized Intersections**	The Eco-Approach and Departure at Signalized Intersections application uses wireless data communications sent from roadside equipment (RSE) to vehicles and encourages green approaches to signalized intersections, including broadcasting signal phase and timing (SPaT) and geographic information description (GID). The application also considers vehicle status messages, sent from nearby vehicles using V2V communications. Upon receiving this information, onboard equipment (OBE) units perform calculations to provide speed advice to the vehicle driver, allowing the driver to adapt the vehicle's speed to pass the next traffic signal on green or to decelerate to a stop in the most eco-friendly manner. This application also considers a vehicle's acceleration as it departs from a signalized intersection.
2	**Eco-Traffic Signal Timing**	The Eco-Traffic Signal Timing application is similar to current adaptive traffic signal control systems; however, the application's objective is explicitly to optimize traffic signals for the environment rather than the current adaptive systems' objective, which is to enhance the intersection level of service or throughput, which might improve the intersection's environmental performance. The Eco-Traffic Signal Timing application processes real-time and historical connected vehicle data at signalized intersections to reduce fuel consumption and overall emissions at the intersection, along a corridor, or for a region. The application evaluates traffic and environmental parameters at each intersection in real time and adapts so that the traffic network is optimized using available green time to serve the actual traffic demands while minimizing the environmental impact.
3	**Eco-Transit Signal Priority**	The Eco-Transit Signal Priority application allows a transit vehicle approaching a signalized intersection to request signal priority. The application considers a host of relevant parameters to determine whether signal priority should be granted. These parameters include the vehicle's location, speed, vehicle powertrain type, mass, grade, and associated modal GHG and criteria air pollutant emissions. Information collected from other vehicles approaching the intersection, a transit vehicle's adherence to its schedule, or the number of passengers on the transit vehicle may also be considered in granting priority. If priority is granted, the traffic signal holds the green on the approach until the transit vehicle clears the intersection. This application does not consider signal preemption, which is reserved for emergency response vehicles.

No.	Application	Description
4	**Eco-Freight Signal Priority**	The Eco-Freight Signal Priority application allows freight vehicles approaching a signalized intersection to request signal priority to reduce emissions in much the same manner as the Eco-Transit Signal Priority. Additional parameters may include schedule status and hazardous material status. If priority is granted, the traffic signal holds the green on the approach until the freight vehicle clears the intersection. Granting of freight signal priority is based on multiple variables, with the objective of producing the least amount of emissions at the signalized intersection, corridor, or network. This application does not consider signal preemption, which is reserved for emergency response vehicles.
5	**Connected Eco-Driving**	The Connected Eco-Driving application provides customized real-time driving advice to drivers, allowing them to adjust behaviors to save fuel and reduce emissions. This advice includes recommended driving speeds, optimal acceleration and deceleration profiles based on prevailing traffic conditions, and local interactions with nearby vehicles. The application also provides feedback to drivers on their driving behavior to encourage them to drive in a more environmentally efficient manner. Finally, the application may also consider vehicle-assisted strategies, where the vehicle automatically implements the eco-driving strategy (e.g., changes gears, switches power sources, or reduces its speed in an eco-friendly manner as the vehicle approaches a traffic signal).

DYNAMIC ECO-LANES TRANSFORMATIVE CONCEPT

The Dynamic Eco-Lanes Transformative Concept features dedicated lanes optimized for the environment, referred to as eco-lanes. Eco-lanes are similar to high-occupancy vehicle (HOV) lanes and are optimized for the environment through the use of connected vehicle data. These lanes are targeted toward low-emission, high-occupancy, freight, transit, and alternative-fuel vehicles (AFV). Drivers are able to opt in to these dedicated eco-lanes to take advantage of eco-friendly applications such as eco-cooperative adaptive cruise control (ACC) and connected eco-driving applications. At the heart of this Transformative Concept are applications that support the operation of dynamic eco-lanes, including establishing criteria for entering the lanes and defining or geo-fencing the eco-lane boundaries, allowing the lanes to be dynamic. The Dynamic Eco-Lanes Transformative Concept features six applications:

- Dynamic Eco-Lanes
- Eco-Speed Harmonization
- Eco-Cooperative Adaptive Cruise Control
- Eco-Ramp Metering
- Connected Eco-Driving
- Multi-Modal Traveler Information

At the heart of this Transformative Concept is an administrative application that supports the operation of Dynamic Eco-Lanes including establishing criteria for entering the lanes and defining or geo-fencing the Eco-Lanes boundaries. This allows the lanes to be dynamic. Eco-Lanes criteria may include the types of vehicles allowed in the Eco-Lanes, emissions criteria for entering the Eco-Lanes, number of lanes, and the start and end of the Eco-Lanes. The application also conveys pre-trip and en-route traveler information about Dynamic Eco-Lanes to travelers.

Dynamic Eco-Lanes would leverage operational strategies implemented by the operating entity (e.g., Traffic Management Center) to reduce vehicle emissions in the lanes. This includes operational strategies such as eco-speed harmonization and eco-ramp metering. Once in the Eco-Lanes, drivers would be provided with speeds limits optimized for the environment. These eco-speed limits would be implemented to help to reduce unnecessary vehicle stops and starts by maintaining consistent speeds, thus reducing GHG and other emissions. Eco-Ramp Metering applications determine the most environmentally efficient operation of traffic signals at freeway on-ramps to manage the rate of vehicles entering the freeway.

Eco-Cooperative Adaptive Cruise Control applications allow individual drivers to opt-into applications that provide cruise control capabilities designed to minimize vehicle accelerations and decelerations for the benefit of reducing fuel consumption and vehicle emissions. These applications consider terrain, roadway geometry, and vehicle interactions to determine a driving speed for a given vehicle that uses the momentum of the vehicle, when suitable, to avoid unnecessary accelerations and reduce emissions. Connected Vehicle platooning is also considered as part of this application.

Finally, Connected Eco-Driving Applications provide customized real-time driving advice to drivers so that they can adjust their driving behavior to save fuel and reduce emissions while driving on freeway. This advice includes recommended driving speeds, optimal acceleration, and optimal decelerations profiles based on prevailing traffic conditions and interactions with nearby vehicles.

Table 2. Dynamic Eco-Lanes Applications

NO.	APPLICATION	DESCRIPTION
6	**Dynamic Eco-Lanes**	Dynamic eco-lanes are similar to current HOV lanes. They are optimized for the environment and encourage use by low-emission, high-occupancy, freight, transit, and alternative-fuel or regular vehicles operating in eco-friendly ways (i.e., eco-speed limits, vehicle platooning). The Dynamic Eco-Lanes application establishes criteria and defines or geo-fences the eco-lanes boundaries. Eco-Lanes criteria may include the types of vehicles allowed in the eco-lanes, emissions criteria for entering the eco-lanes, the number of lanes, and the start and end of the eco-lanes. The application also conveys pre-trip and en route traveler information about dynamic eco-lanes to travelers, including information about criteria for vehicles to enter the eco-lanes, current and predicted traffic conditions in the eco-lanes, and geographic boundaries of the eco-lanes.
7	**Eco-Speed Harmonization**	The Eco-Speed Harmonization application determines eco-speed limits based on traffic conditions, weather information, and GHG and criteria pollutant information from the CVE. The purpose of speed harmonization is to dynamically change speed limit on links that approach areas of traffic congestion, bottlenecks, incidents, special events, and other conditions that affect flow. Speed harmonization assists in maintaining flow, reducing unnecessary stops and starts, and maintaining consistent speeds, thus reducing fuel consumption, GHG emissions, and other emissions on the roadway. Eco-speed limits can be broadcast and received by OBE units or displayed on variable speed limit (VSL) signs located along the roadway. This application is similar to current VSL applications, although the speed recommendations seek to minimize emissions and fuel consumption along the roadway.

No.	Application	Description
8	**Eco-Cooperative Adaptive Cruise Control**	The Eco-Cooperative Adaptive Cruise Control application automatically controls the speed of a vehicle using V2V communications to transmit a vehicle's instantaneous speed to following vehicles. This application allows following vehicles to use ACC aimed at relieving a driver from manually adjusting his or her speed to maintain a constant speed and a safe time gap from the lead vehicle. One feature of an eco-cooperative ACC system is that time gaps can be safely shortened by automated throttle control and V2V connectivity. This enables increased freeway capacity in an eco-friendly manner. The Eco-Cooperative Adaptive Cruise Control application incorporates other information, such as road grade, roadway geometry, and road weather information, to determine the most environmentally efficient trajectory for the following vehicle. In the long term, the application may also consider vehicle platoons, where two or more vehicles travel with small gaps, reducing aerodynamic drag. Platooning relies on V2V communication that allows vehicles to accelerate or brake with minimal lag to maintain the platoon with the lead vehicle. The reduction in drag results in reduced fuel consumption, greater fuel efficiency, and less pollution for vehicles. This application is applicable to all vehicle classes.
9	**Eco-Ramp Metering**	The Eco-Ramp Metering application determines the most environmentally efficient operation of traffic signals at freeway on-ramps to manage the rate of entering automobiles. This application collects traffic and environmental data from the CVE to allow on-ramp merge operations that minimize overall emissions, including traffic and environmental conditions on the ramp and on the freeway upstream and downstream of the ramp. Using this information, the application determines a timing plan for the ramp meter based on current and predicted traffic and environmental conditions. The objective for this application is to produce timing plans that reduce overall emissions, including reducing emissions from bottlenecks forming on the freeway as well as emissions from vehicles on the ramp.
10	**Connected Eco-Driving**	The Connected Eco-Driving application provides customized real-time driving advice to drivers, allowing them to adjust behaviors to save fuel and reduce emissions. This advice includes recommended driving speeds, optimal acceleration and deceleration profiles based on prevailing traffic conditions, and more local interactions with nearby vehicles. Finally, the application may also consider vehicle-assisted strategies, where the vehicle automatically implements the eco-driving strategy (i.e., change gears, switch power sources, or reduce speed in an eco-friendly manner as the vehicle approaches a traffic signal).

No.	Application	Description
11	**Multi-Modal Traveler Information**	The Multi-Modal Traveler Information application provides pre-trip and en route multimodal traveler information to encourage transportation choices with reduced environmental impacts. The application collects traffic and environmental data from connected vehicles and other sources and uses it to determine real-time or predicted traffic conditions. This information is provided to travelers so they can either plan to or dynamically adjust departure times or mode choices or select an alternate route. Traffic conditions include information about roadway speeds and travel times as well as predicted traffic conditions. Travelers can use this information to adjust their departure time or select an alternate route. Another key component of this application is providing travelers with transit options to encourage mode shift, including information about transit schedules and real-time transit vehicle arrival and departure times.

DYNAMIC LOW EMISSIONS ZONES TRANSFORMATIVE CONCEPT

The Dynamic Low Emissions Zone Transformative Concept includes a geographically defined area that seeks to restrict or deter access by specific categories of high-polluting vehicles to improve the air quality within the geographic area. The low-emissions zone can be dynamic, allowing the operating entity to change the location, boundaries, fees, or time of the low-emissions zone. At the heart of this Transformative Concept is a Dynamic Emissions Pricing application, which leverages connected vehicle technologies to dynamically determine fees for vehicles entering the low-emissions zone. These fees may be based on the vehicle's engine emissions standard or emissions data collected directly from the vehicle using V2I communications. To encourage travelers entering the zone to use public transportation, policy can be in place to waive fees for transit vehicles entering the low-emissions zone. The Dynamic Low-Emissions Zones Transformative Concept features three applications:

- Dynamic Emissions Pricing
- Connected Eco-Driving
- Multi-Modal Traveler Information

This Transformative Concept also provides the capability for the Low Emissions Zone to be dynamic or allowing the operating entity to change the location or time of the Low Emissions Zone. For example, this would allow the Dynamic Low Emissions Zone be commissioned based on various criteria including atmospheric conditions, weather conditions, or special events.

Pre-trip and en-route traveler information is also a critical component of this Transformative Concept. This includes information about criteria for vehicles to enter the Low Emissions Zone, expected fees and incentives for their trip, current and predictive traffic conditions, and the geographic boundaries of the Low Emissions Zone. Finally, Connected Eco-Driving applications are encouraged 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.

Table 3. Dynamic Low Emissions Zones Applications

No.	Application	Description
12	**Dynamic Emissions Pricing**	The Dynamic Emissions Pricing application supports the establishment and operation of dynamic low-emissions zones based on traffic and environmental data collected from vehicles using connected vehicle technologies and RSE. Low-emissions zones are similar to current cordon pricing strategies. They are dynamic and less dependent on conventional ITS infrastructure. Low-emissions zone criteria may include the types of vehicles allowed in the zone, exemptions for transit vehicles, emissions criteria for entering the zone, fees or incentives for vehicles based on emissions data collected from the vehicle, and geo-fenced boundaries. Electronic toll-collection functions are also considered. These functions support payments of fees or tolls by electronically debiting the accounts of registered vehicles using connected vehicle technologies. Finally, this application conveys pre-trip and en route traveler information about the low-emissions zone to travelers, including information about criteria for entering the zone, expected fees and incentives, current and predicted traffic conditions, and geographic boundaries of the zone.
13	**Connected Eco-Driving**	The Connected Eco-Driving application provides customized real-time driving advice to drivers, allowing them to adjust behaviors to save fuel and reduce emissions. This advice includes recommended driving speeds, optimal acceleration and deceleration profiles based on prevailing traffic conditions, and local interactions with nearby vehicles. The application also provides feedback to drivers on their driving behavior to encourage more eco-driving. Finally, the application may also consider vehicle-assisted strategies, where the vehicle automatically implements the eco-driving strategy (i.e., change gears, switch power sources, or reduce speed in an eco-friendly manner as the vehicle approaches a traffic signal).
14	**Multi-Modal Traveler Information**	The Multi-Modal Traveler Information application provides pre-trip and en route multimodal traveler information to encourage transportation choices with reduced environmental impacts. The application collects traffic and environmental data from connected vehicles and other sources and uses it to determine real-time or predictive traffic conditions. This information is provided to travelers so they can either plan to or dynamically adjust departure time and mode choices or select an alternate route. Traffic conditions include information about roadway speeds and travel times and the forecasting of traffic conditions. Travelers can use this information to adjust their departure time or select an alternate route. Another key component of this application is to provide travelers with transit options to encourage mode shift, including information about transit schedules and real-time transit vehicle arrival and departure times.

SUPPORT ALTERNATIVE FUEL VEHICLE OPERATIONS TRANSFORMATIVE CONCEPT

The Support for Alternative Fuel Vehicle Operations Transformative Concept supports operations of vehicles that run on a fuel other than petroleum. Examples include vehicles whose engines do not solely use oil-based fuels, such as electric cars, hybrid-electric vehicles, and fuel-cell vehicles. The concept also considers a CVE that uses Smart Grid, which is the electrical grid that uses technology to gather and automatically act on information to improve the efficiency, reliability, and sustainability in the production and distribution of electricity. This Transformative Concept includes two applications:

- Engine Performance Optimization
- AFV Charging/Fueling

These applications collect pertinent environmental data and adjust engine operations to optimize both fuel economy and emissions performance. Information about prevailing traffic conditions, weather conditions, or road grade may also be used as input for optimizing the engines performance. For example, engine adjustments would be made in real-time on the vehicle to reduce emissions during high ozone alert days or during extremely hot or cold temperatures.

AFV Charging/Fueling applications provide travelers with information about the locations of AFV charging/fueling stations including inductive charging infrastructure. These applications would provide users with information about the availability of charging infrastructure at the stations and would allow users to make reservations at charging/fueling stations and allow for electronic payment using connected vehicle technologies. Finally, these applications also consider the transmission of AFV-specific information as part of MAYDAY messages when a vehicle is in an incident or requires emergency assistance.

Inductive charging for electric vehicles is also considered as part of this Transformative Concept. This 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 or a stop sign. It also supports charging vehicles moving at highway speeds.

Table 4. Support for Alternative Fuel Vehicle Operations Applications

No.	Application	Description
15	**Engine Performance Optimization**	The Engine Performance Optimization application resides in individual vehicles to adapt engine performance to minimize emissions based on information collected from the vehicle's diagnostic systems and the CVE. The application collects pertinent environmental data and adjusts engine operations to optimize both fuel economy and emissions performance. Information about prevailing traffic conditions, weather conditions, or road grade is also used as input for optimizing the engine's performance. For example, real-time engine adjustments are made on the vehicle to reduce emissions during high-ozone alert days or during extremely hot or cold temperatures.
16	**AFV Charging / Fueling**	The AFV Charging/Fueling application informs travelers with locations and the availability of AFV charging and fueling stations and inductive charging infrastructure. The application informs travelers and enables reservations. It also supports connection to the Smart Grid. In addition to providing travelers with information about charging stations, this application supports inductive charging for electric vehicles, including roadside infrastructure deployed along the roadway to support charging still vehicles and vehicles moving at highway speeds. Electronic payment for inductive charging is also included in this application.

ECO-TRAVELER INFORMATION TRANSFORMATIVE CONCEPT

The Eco-Traveler Information Transformative Concept enables development of new, advanced traveler information applications through integrated, multisource, multimodal data. Although the AERIS Program may not directly develop specific traveler information applications, an open data/open source approach is intended to engage researchers and the private sector to spur innovation and environmental applications. This Transformative Concept includes six applications:

- Dynamic Eco-Routing
- Dynamic Eco-Transit Routing
- Dynamic Eco-Freight Routing
- Eco-Smart Parking
- Connected Eco-Driving
- Multi-Modal Traveler Information

Eco-Routing applications determine the most eco-friendly route, in terms of minimum fuel consumption or emissions, between a trip origin and a destination for individual travelers. The application uses historical, real-time, and predictive traffic and environmental data collected from vehicles using connected vehicle technologies to determine the vehicle's optimal eco-route between its origin and destination. These applications may be customized for transit or freight operations.

Eco-Smart Parking applications provide travelers with real-time parking information including information about the location, availability, type (e.g., AFV only, street parking, garage parking) and price of parking. The application reduces the time required for drivers to search for a parking space thereby reducing emissions and also provides incentives to use AFVs

Connected Eco-Driving application provides customized real-time driving advice to drivers so that they can adjust their driving behavior to save fuel and reduce emissions. This advice includes recommended driving speeds, optimal acceleration and deceleration profiles based on prevailing traffic conditions and interactions with nearby vehicles. The application also provides feedback to drivers on their driving behavior to encourage drivers to drive in a more environmentally efficient manner.

Finally, Multi-Modal Traveler Information applications provide pre-trip and en-route multi-modal traveler information to encourage environmentally friendly transportation choices. These applications collect traffic and environmental data from connected vehicles and other sources and use these data to determine real-time or predicted traffic conditions which are then provided to travelers. This information may be used by travelers to adjust their departure time or to select an alternate route. Another key component of this application is providing travelers with transit options to encourage mode shift.

Table 5. Eco-Traveler Information Applications

No.	Application	Description
17	**Dynamic Eco-Routing**	The Dynamic Eco-Routing application determines the most eco-friendly route, in terms of minimum fuel consumption or emissions, for individual travelers. This application is similar to current navigation systems, which determine the route based on the shortest path or minimum time. This application also recommends routes that produce the fewest emissions or reduce fuel consumption based on historical, real-time, and predicted traffic and environmental data (e.g., prevailing weather conditions).
18	**Dynamic Eco-Transit Routing**	The Dynamic Eco-Transit Routing application is similar to the Dynamic Eco-Routing application but is focused rather on providing guidance on the most eco-friendly route that minimizes fuel consumption and emissions for transit vehicles along their routes. This application considers both fixed transit routes and paratransit. Because transit vehicles may need to adhere to fixed routes, they may not be as flexible in altering their routes as personal vehicles. The application uses historical, real-time, and predicted traffic and environmental data collected from vehicles using connected vehicle technologies to determine the vehicle's eco-route between its origin and destination.
19	**Dynamic Eco-Freight Routing**	The Dynamic Eco-Freight Routing application is similar to the Dynamic Eco-Routing application but is focused on providing guidance on the most eco-friendly route that minimizes fuel consumption or emissions for all classes of freight vehicles. The application uses historical, real-time, and predicted traffic and environmental data collected from vehicles using connected vehicle technologies to determine the vehicle's eco-route between its origin and destination. Information about the freight vehicle's deliveries and schedule may also be included in determining the eco-route.
20	**Eco-Smart Parking**	The Eco-Smart Parking application provides users with real-time location, availability, type (e.g., AFV only, street, garage), and price of parking. The application reduces time required for drivers to search for a parking space, thereby reducing emissions, and also provides incentives to use AFVs. The application also supports dynamic pricing of parking based on emissions, vehicle type, and demand. Finally, this application allows travelers to reserve parking spaces.

No.	Application	Description
21	**Connected Eco-Driving**	The Connected Eco-Driving application provides customized real-time driving advice to drivers, allowing them to adjust behaviors to save fuel and reduce emissions. This advice includes recommended driving speeds, optimal acceleration and deceleration profiles based on prevailing traffic conditions, and local interactions with nearby vehicles. The application also provides feedback to drivers on their driving behavior to encourage them to drive in a more environmentally efficient manner. Finally, the application may also consider vehicle-assisted strategies, where the vehicle automatically implements the eco-driving strategy (i.e., change gears, switch power sources, or reduce speed in an eco-friendly manner as the vehicle approaches a traffic signal).
22	**Multi-Modal Traveler Information**	The Multi-Modal Traveler Information application provides pre-trip and en route multimodal traveler information to encourage transportation choices with reduced environmental impacts. The application collects traffic and environmental data from connected vehicles and other sources and uses it to determine real-time or predictive traffic conditions. This information is provided to travelers so that they can either plan to or dynamically adjust departure time and mode choices or select an alternate route. Traffic conditions include information about roadway speeds and travel times as well as the forecasting of traffic conditions. Travelers can use this information to adjust their departure time or to select an alternate route. Another key component of this application is to provide travelers with transit options to encourage mode shift, including information about transit schedules and real-time transit vehicle arrival and departure times.

ECO-INTEGRATED CORRIDOR MANAGEMENT TRANSFORMATIVE CONCEPT

The Eco-Integrated Corridor Management (Eco-ICM) Transformative Concept includes the integrated operation of a major travel corridor to reduce transportation-related emissions on arterials and freeways. *Integrated operations* means partnering among operators of various surface transportation agencies to treat travel corridors as an integrated asset, coordinating their operations simultaneously with a focus on decreasing fuel consumption, GHG emissions, and criteria air pollutant emissions. At the heart of this Transformative Concept is a real-time data-fusion and decision support system that involves using multisource, real-time V2I data on arterials, freeways, and transit systems to determine which operational decisions have the greatest environmental benefit to the corridor. This Transformative Concept includes a combination of multimodal applications that together provide an overall environmental benefit to the corridor. This Transformative Concept will be further defined after analysis of the other Transformative Concepts is completed.

Table 6. Eco-ICM Applications

No.	Application	Description
23	**Eco-Integrated Corridor Management Decision Support System**	The Eco-Integrated Corridor Management Decision Support System application involves using historical, real-time, and predictive traffic and environmental data on arterials, freeways, and transit systems to determine operational decisions that are environmentally beneficial to the corridor. The Eco-Integrated Corridor Management (Eco-ICM) Decision Support System is a data-fusion system that collects information from various multimodal systems. Data from these systems is then used to determine operational strategies for arterials, freeways, and transit that minimize the environment impact of the corridor. For example, on a code red air quality day, the Eco-ICM Decision Support System may recommend eco-signal timing plans, eco-ramp metering strategies, eco-speed limits, and recommendations for increased transit service.