UNITED STATES
DEPARTMENT OF TRANSPORTATION

Eco-Signal Operations

Concept of Operations

Applications for the Environment: Real-Time Information Synthesis (AERIS)

Adapted from the Eco-Signal Operations Concept of Operations Document

AERIS

AERIS Operational Scenarios

ECO-SIGNAL OPERATIONS

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.

ECO-LANES

Dedicated freeway lanes – similar to HOV lanes – optimized for the environment that encourage use from vehicles operating in eco-friendly ways. The lanes may support variable speed limits, eco-cooperative adaptive cruise control (ECACC) and vehicle platooning applications, and wireless inductive/resonance charging infrastructure embedded in the roadway.

LOW EMISSIONS ZONES

Geographically defined areas that seek to incentivize “green transportation choices” or restrict specific categories of high-polluting vehicles from entering the zone to improve the air quality within the geographic area. Geo-fencing the boundaries allows the possibility for these areas to be responsive to real-time traffic and environmental conditions.

ECO-TRAVELER INFORMATION

Applications that enable development of new, advanced traveler information applications through integrated, multisource, multimodal data. An open data/open source approach is intended to spur innovation and environmental traveler information applications. Eco-Traveler Information applications include applications that assist users with finding charging stations for alternative fuel vehicles, parking applications, and eco-routing applications.

ECO-INTEGRATED CORRIDOR MANAGEMENT

Considers 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 and emissions.

Eco-Signal Operations

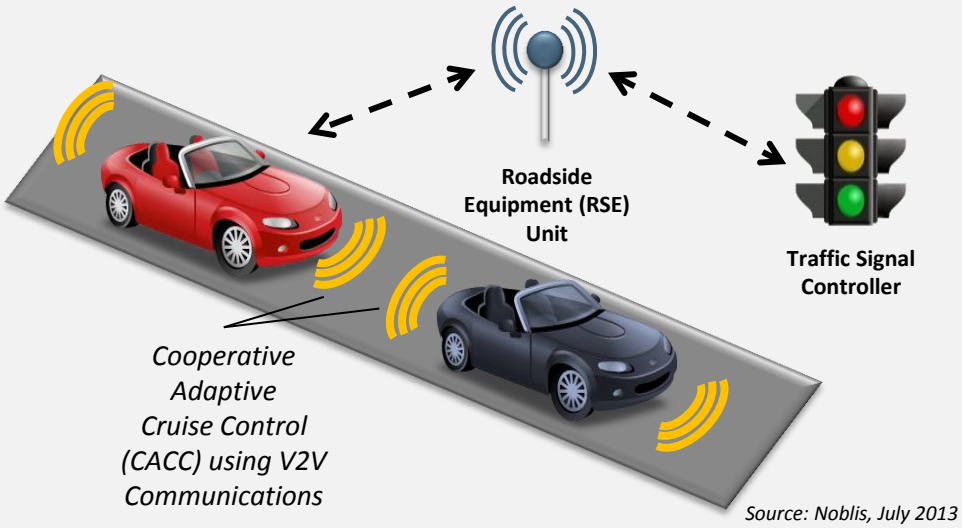
Operational Scenario Description

- 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 Operational Scenario features the following applications: (1) Eco-Approach and Departure at Signalized Intersections, (2) Eco-Traffic Signal Timing, (3) Eco-Traffic Signal Priority, (4) Wireless Inductive/Resonance Charging, and (5) Connected Eco-Driving.

Potential Benefits

- Eco-Approach and Departure at Signalized Intersections[1]
  - Uncoordinated: Provides 5-10% benefits for an uncoordinated corridor.
  - Coordinated: Provides up to 12-13% fuel reduction benefits above the baseline
    - 8% of this fuel reduction benefit is attributable to simply coordinating the signals (without the eco approach and departure application in use)
    - 4-5% attributable to the Eco approach and departure application
  - When considering CACC capabilities, it is possible to achieve 21.84% reduction.

Operational Scenario Visualization



Source: Noblis, July 2013

Eco-Signal Operations Applications

Application Description

Eco-Traffic Signal Timing

This application is similar to current traffic signal systems; however the application's objective is to optimize the performance of traffic signals for the environment. The application collects data from vehicles, such as vehicle location, speed, and emissions data using connected vehicle technologies. It then processes these data to develop signal timing strategies focused on reducing 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 the traffic network is optimized using available green time to serve the actual traffic demands while minimizing the environmental impact.

Eco-Approach and Departure at Signalized Intersections

This application uses wireless data communications sent from a roadside equipment (RSE) unit to connected vehicles to encourage "green" approaches to signalized intersections. The application, located in a vehicle, collects signal phase and timing (SPaT) and Geographic Information Description (GID) messages using V2I communications and data from nearby vehicles using V2V communications. Upon receiving these messages, the application would perform calculations to determine the vehicle's optimal speed to pass the next traffic signal on a green light or to decelerate to a stop in the most eco-friendly manner. This information is then sent to longitudinal vehicle control capabilities in the vehicle to support partial automation. The application also considers a vehicle's acceleration as it departs from a signalized intersection and engine start-stop technologies.

Eco-Traffic Signal Priority

This application allows 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 emissions to determine whether priority should be granted. Information collected from vehicles approaching the intersection, such as a transit vehicle's adherence to its schedule, the number of passengers on the transit vehicle, or weight of a truck may also be considered in granting priority. If priority is granted, the traffic signal would hold the green on the approach until the transit or freight vehicle clears the intersection. This application does not consider signal pre-emption, which is reserved for emergency response vehicles.

Eco-Signal Operations Applications

Application Description

Connected Eco-Driving

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

Wireless Inductive/Resonance Charging

Wireless inductive/resonance charging includes 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 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 signal or a stop sign. It also supports charging vehicles moving at highway speeds.

Goals and Objectives

Goal #1: Reduce Environmental Impacts	Goal #2: Support "Green Transportation Decisions" by Travelers and Operating Entities	Goal #3: Enhance Mobility of the Transportation System *(secondary goal)*	Goal #4: Improve the Safety of the Transportation System *(secondary goal)*

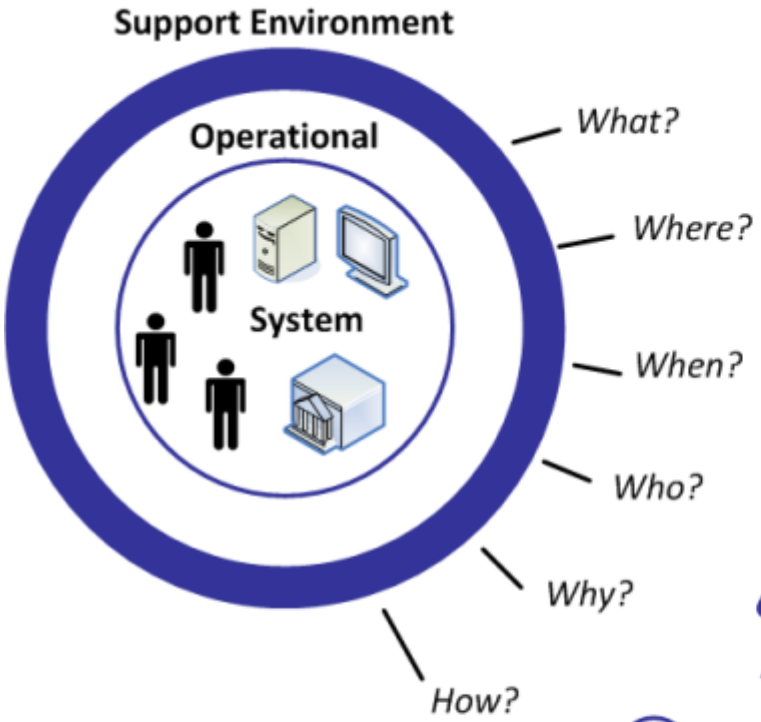
• **Reduce Emissions from Surface Transportation Vehicles**
  • Reduce CO_2, CO, NO_X, SO_2, PM_{10}, $PM_{2.5}$, VOCs
 	
• **Reduce Energy Consumption Associated with Surface Transportation Vehicles**
  • Reduce excess fuel
  • Reduce energy consumption
	• **Increase Eco-Driving Awareness and Practice**
	  • Increase the numbers of drivers practicing eco-driving strategies
	  • Increase the number of eco-driving marketing/outreach activities
	
	• **Reduce Range Anxiety for Drivers Driving Electric Vehicles**
	  • Reduce Drivers fear of Range Anxiety
	
	• **Increase the Range of Electric Vehicles**
	  • Increase the distance that electric vehicles can travel without stopping at a charging station
		• **Improve the Efficiency of the Transportation System**
		  • Reduce delay per person
		  • Decrease control delay per vehicle on arterials
		  • Increase miles of arterials operating at LOS 'X'
		
		• **Improve Transit Operating Efficiency**
		  • Reduce transit travel times
		  • Decrease signal delay on transit routes
		  • Increase the implementation of transit signal priority
		
		• **Improve Freight Operating Efficiency**
		  • Reduce delay on freight-significant routes
		  • Increase customer satisfaction
			• **Reduce Crashes, Injuries, and Fatalities on Arterials**
			  • Reduce crashes, injuries, and fatalities at signalized intersections
			  • Reduce secondary crashes, injuries, and fatalities at signalized intersections
			  • Reduce crashes, injuries, and fatalities due to red-light running
			  • Reduce crashes, injuries, and fatalities due to adverse road weather conditions
			  • Reduce crashes, injuries, and fatalities at railroad crossings

Concept of Operations (ConOps)

- Provides an operational description of “how” the Operational Scenarios may operate
- Builds consensus among AERIS user groups and stakeholders concerning needs and expectations of:
  - USDOT
  - State and Local Departments of Transportation (DOTs)
  - Regional Planning Organizations
  - The Automotive Industry
  - ITS Developers, Integrators, and Researchers
- Serves as a guideline moving forward with research and development of AERIS applications

AERIS Concepts of Operations are intended to be a blueprint describing the Operational Scenarios so all stakeholders can understand how they may work

Conceptual Representation of a ConOps



Note: Graphic adapted from ANSI/AIAA's "Guide for the Preparation of Operational Concept Documents" ANSI/AIAA G-043-1992)

AERIS Concept of Operations

- AERIS Concept of Operations documents are intended to convey "transformational ideas" that will be modeled to show the potential environmental benefits that can be achieved through connected vehicle applications

- AERIS Concept of Operations are "generalized" and not specific to:
  - Geographic area
  - Operating entity (e.g., state or local DOT)
  - Existing systems that may be in place
  - Operating procedures
  - Political environment

Defining the System

ECO-TRAFFIC SIGNAL SYSTEM

IN-VEHICLE SYSTEM

Back-Office System

- Most likely resides in a Traffic Management Center
- Developed by state and local DOTs and ITS developers
- Integrated with existing ITS systems (i.e., Traffic Signal System operating platforms)
- Collect V2I messages (e.g., probe messages and environmental messages)
- Processes connected vehicle and 'conventional' data
- Implements operational strategies (e.g., traffic signal timing plans, eco-speed limits, etc.)
- Provides traffic conditions, environmental conditions, and GID messages to Roadside Equipment

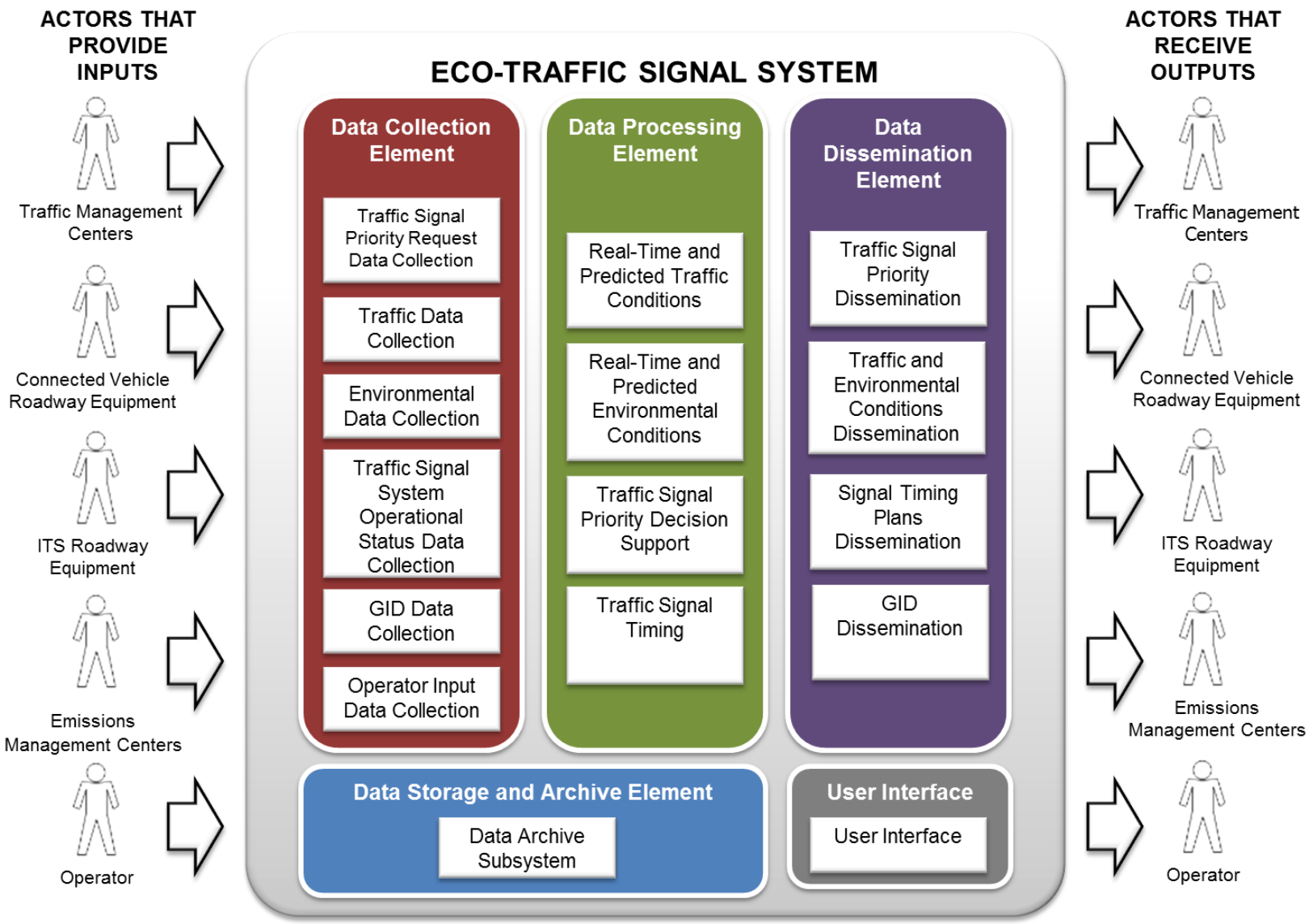
In-Vehicle System

- Resides in the vehicle
- Developed by automobile OEMs or aftermarket device vendors.
- Collects vehicle diagnostics data, V2V, and V2I messages
- Provides V2V messages to other vehicles
- Provides V2I messages to Connected Vehicle Roadway Equipment
- Implements eco-driving strategies (e.g., eco-approach to a traffic signal)

Eco-Traffic Signal System

Similar to current traffic signal systems, but uses connected vehicle technologies to help optimize traffic signals for the environment. The system:

1. Gathers traffic and environmental data from multiple sources including ITS Roadway Equipment, Connected Vehicle Roadway Equipment, and other systems.
2. Processes these data to develop operational strategies at signalized intersections, focused on reducing fuel consumption and overall emissions at the intersection, along a corridor, or for a region.
3. Evaluates traffic and environmental parameters at each intersection every cycle in real-time and adapts to fluctuating traffic and environmental conditions through its optimization algorithm.
4. Readily adapts signal control to actual traffic volumes and environmental conditions so that the traffic network operation is optimized using available green time to serve the actual traffic demands while minimizing the environmental impact.
5. Supports eco-traffic signal priority.


ACTORS THAT PROVIDE INPUTS
Traffic Management Centers
Connected Vehicle Roadway Equipment
ITS Roadway Equipment
Emissions Management Centers
Operator
ECO-TRAFFIC SIGNAL SYSTEM
Data Collection Element
Traffic Signal Priority Request Data Collection
Traffic Data Collection
Environmental Data Collection
Traffic Signal System Operational Status Data Collection
GID Data Collection
Operator Input Data Collection
Data Processing Element
Real-Time and Predicted Traffic Conditions
Real-Time and Predicted Environmental Conditions
Traffic Signal Priority Decision Support
Traffic Signal Timing
Data Dissemination Element
Traffic Signal Priority Dissemination
Traffic and Environmental Conditions Dissemination
Signal Timing Plans Dissemination
GID Dissemination
Data Storage and Archive Element
Data Archive Subsystem
User Interface
User Interface
ACTORS THAT RECEIVE OUTPUTS
Traffic Management Centers
Connected Vehicle Roadway Equipment
ITS Roadway Equipment
Emissions Management Centers
Operator

Back Office

ECO-TRAFFIC SIGNAL SYSTEM

Data Collection Element

1. ETSS-DC-01: Collect Traffic Signal Priority Requests
2. ETSS-DC-02: Collect Traffic Data
3. ETSS-DC-03: Collect Environmental Data
4. ETSS-DC-04: Collect Traffic Signal Operational Status Data
5. ETSS-DC-05: Collect Geographic Information Description Data
6. ETSS-DC-06: Collect Operator Input

Data Storage and Archive Element

1. ETSS-DA-01: Archive Data
2. ETSS-DA-02: Determine Performance Measures

Data Processing Element

1. ETSS-DP-01: Process Traffic Data
2. ETSS-DP-02: Generate Predicted Traffic Conditions
3. ETSS-DP-03: Process Environmental Data
4. ETSS-DP-04: Generate Predicted Emissions Profile
5. ETSS-DP-05: Provide Traffic Signal Priority Decision Support Capabilities
6. ETSS-DP-06: Generate Traffic Signal Timing Strategy

Data Dissemination Element

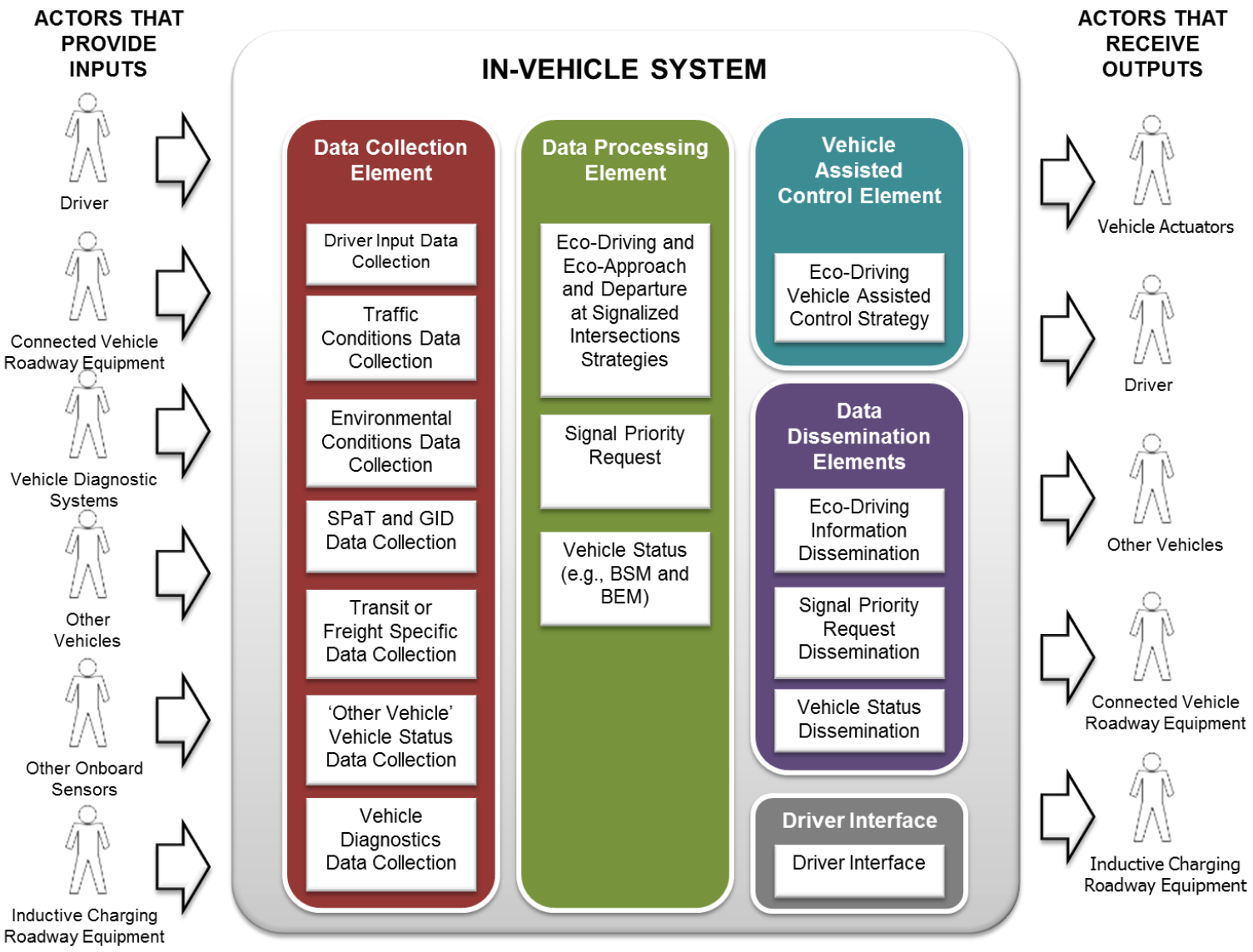
1. ETSS-D-01: Disseminate Traffic Signal Priority Data
2. ETSS-D-02: Disseminate Traffic Information to Other Centers
3. ETSS-D-03: Disseminate Traffic Conditions to Vehicles
4. ETSS-D-04: Disseminate Environmental Conditions to Other Centers
5. ETSS-D-05: Disseminate Environmental Conditions to Vehicles
6. ETSS-D-06: Disseminate Traffic Signal Timing Plans
7. ETSS-D-07: Disseminate Geographic Information Descriptions

User Interface Element

1. ETSS-UI-01: User Interface

In-Vehicle System

- Allows drivers of vehicles to opt-in to applications that provide real-time information so that they can adjust driving behavior to save fuel and reduce emissions.
- Collects traffic data, environmental data, vehicle status data from other vehicles, terrain information, and SPaT information available through DSRC or other wireless communication.
- Processes data to determine optimal eco-driving strategies which in turn are disseminated to the driver through an operator interface.
- Considers start-stop capabilities that automatically shut down and restart the vehicle's engine reducing the amount of time the engine spends idling, thereby reducing fuel consumption and emissions.
- Allows for wireless charging of electric vehicle batteries.
- Provides feedback / analysis of driving behavior including fuel consumption, emissions, and financial savings for a trip.


ACTORS THAT PROVIDE INPUTS
Driver
Connected Vehicle Roadway Equipment
Vehicle Diagnostic Systems
Other Vehicles
Other Onboard Sensors
Inductive Charging Roadway Equipment
IN-VEHICLE SYSTEM
Data Collection Element
Driver Input Data Collection
Traffic Conditions Data Collection
Environmental Conditions Data Collection
SPaT and GID Data Collection
Transit or Freight Specific Data Collection
'Other Vehicle' Vehicle Status Data Collection
Vehicle Diagnostics Data Collection
Data Processing Element
Eco-Driving and Eco-Approach and Departure at Signalized Intersections Strategies
Signal Priority Request
Vehicle Status (e.g., BSM and BEM)
Vehicle Assisted Control Element
Eco-Driving Vehicle Assisted Control Strategy
Data Dissemination Elements
Eco-Driving Information Dissemination
Signal Priority Request Dissemination
Vehicle Status Dissemination
Driver Interface
Driver Interface
ACTORS THAT RECEIVE OUTPUTS
Vehicle Actuators
Driver
Other Vehicles
Connected Vehicle Roadway Equipment
Inductive Charging Roadway Equipment

Vehicle

IN-VEHICLE SYSTEM

Data Collection Element

1. IVS-DC-01: Collect Driver Input
2. IVS-DC-02: Receive Traffic Conditions Data
3. IVS-DC-03: Receive Environmental Conditions Data
4. IVS-DC-04: Collect Signal Phase and Timing (SPaT) Data
5. IVS-DC-05: Collect Geographic Information Descriptions (GID) Data
6. IVS-DC-06: Collect Data for Signal Priority Requests
7. IVS-DC-07: Receive Vehicle Status Data from Other Vehicles (i.e., BSM)
8. IVS-DC-08: Collect Vehicle Diagnostics Data
9. IVS-DC-09: Receive Inductive Charge

Data Processing Element

1. IVS-DP-01: Determine Eco-Driving Recommendations
2. IVS-DP-02: Determine Eco-Approach & Departure at Intersections
3. IVS-DP-03: Determine Traffic Signal Priority Request Strategy
4. IVS-DP-04: Determine Vehicle Emissions and Fuel Consumption Data

Data Dissemination Element

1. IVS-D-01: Provide Eco-Driving Information to the Driver
2. IVS-D-02: Send Traffic Signal Priority Request
3. IVS-D-03: Disseminate Vehicle Status Data (i.e., BSM)
4. IVS-D-04: Disseminate Vehicle Status Environmental Data (i.e., BEM)

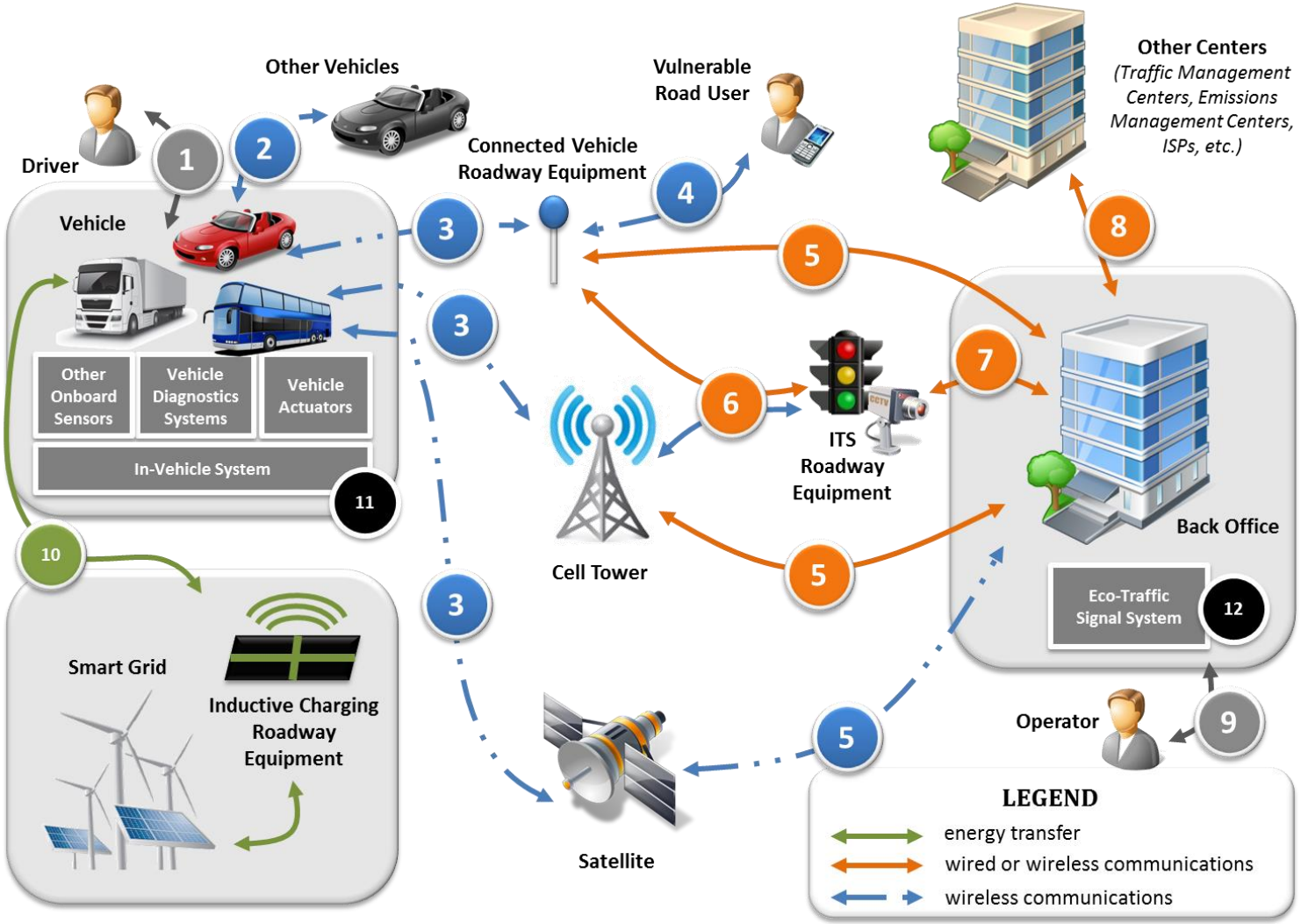
Vehicle Control Element

1. IVS-VC-01: Provide Eco-Driving Vehicle Assisted Control Strategy
2. IVS-VC-02: Provide Start-Stop Capabilities

Driver Interface Element

1. IVS-DI-01: Provide Driver Interface

Eco-Signal Operations

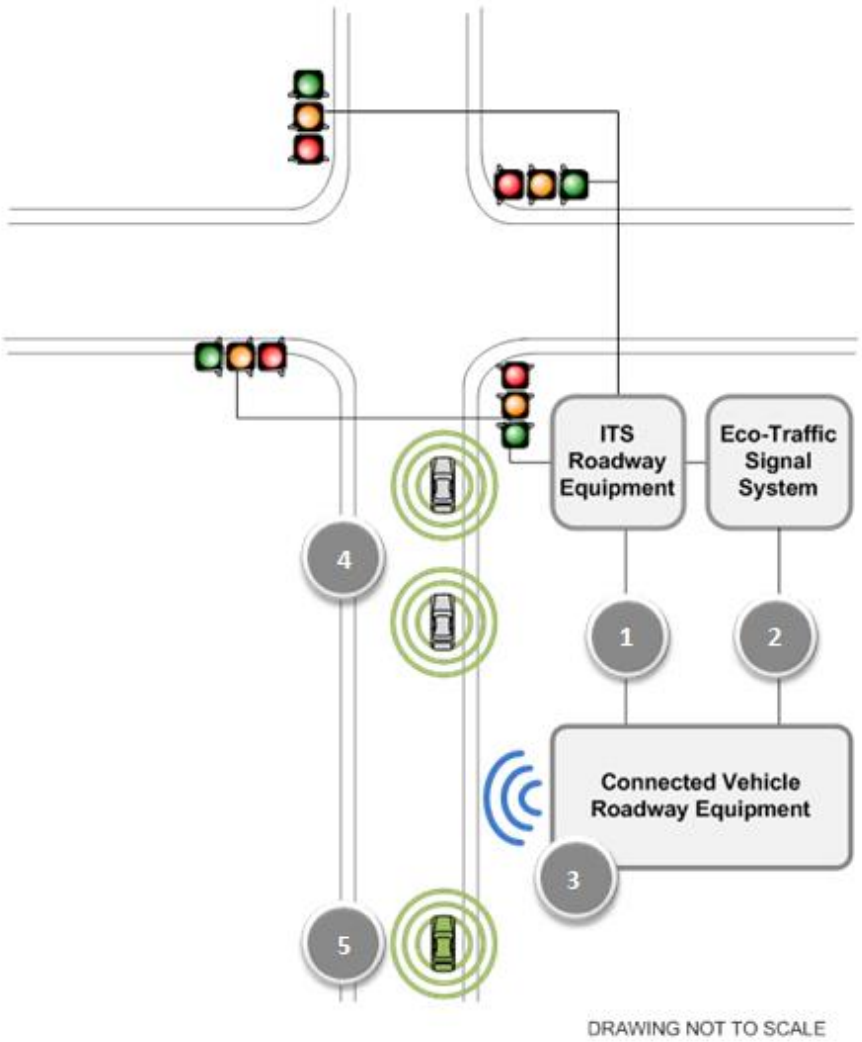


Eco-Signal Operations

Table 8-1: Eco-Signal Operations Interfaces and Data Exchanges

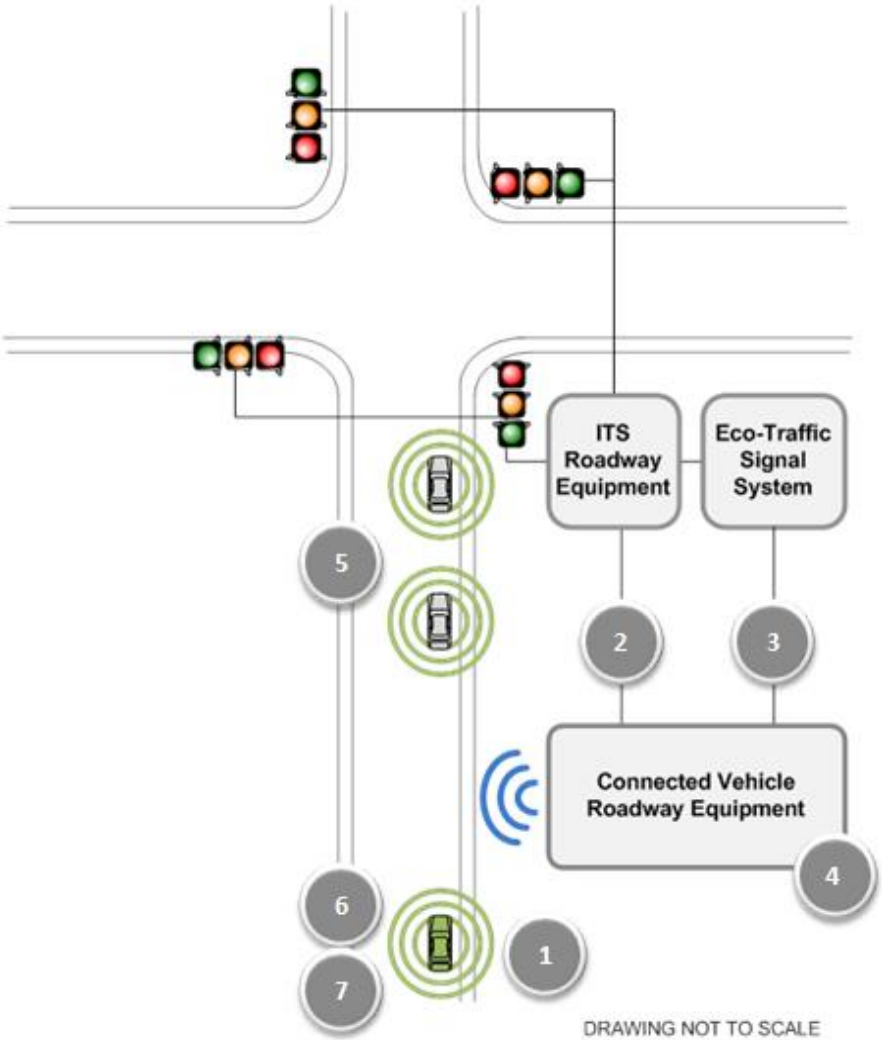
Item	Actors	Data Exchange / Action	Related User Needs
1	In-Vehicle System and Driver	<u>In-Vehicle System sends to Driver</u> • Eco-driving recommendations (e.g., recommended driving speeds, driver feedback, etc.) • SPaT information (e.g., time to red, etc.) • Traffic conditions • Environmental conditions (e.g., code red air quality alerts) • Road weather conditions • Status of an electric vehicle's electric charge and charge received from inductive charging field infrastructure <u>Driver Sends to In-Vehicle System</u> • Activation of Application (e.g., activate eco-driving application) • Updates to configurable parameters	• IVS-DC-01: Collect Driver Input • IVS-D-01: Provide Eco-Driving Information to the Driver • IVS-DI-01: Provide Driver Interface
2	In-Vehicle System and Other Vehicles	<u>In-Vehicle System sends to Other Vehicles</u> • Vehicle status data (e.g., BSM data including vehicle's location, heading, speed, acceleration, braking status, size, etc.) <u>Other Vehicles send to In-Vehicle System</u> • Vehicle status data (e.g., BSM data including vehicle's location, heading, speed, acceleration, braking status, size, etc.)	• IVS-DC-07: Receive Vehicle Status Data from Other Vehicles • IVS-D-03: Disseminate Vehicle Status Information

Eco-Approach and Departure at Signalized Intersections



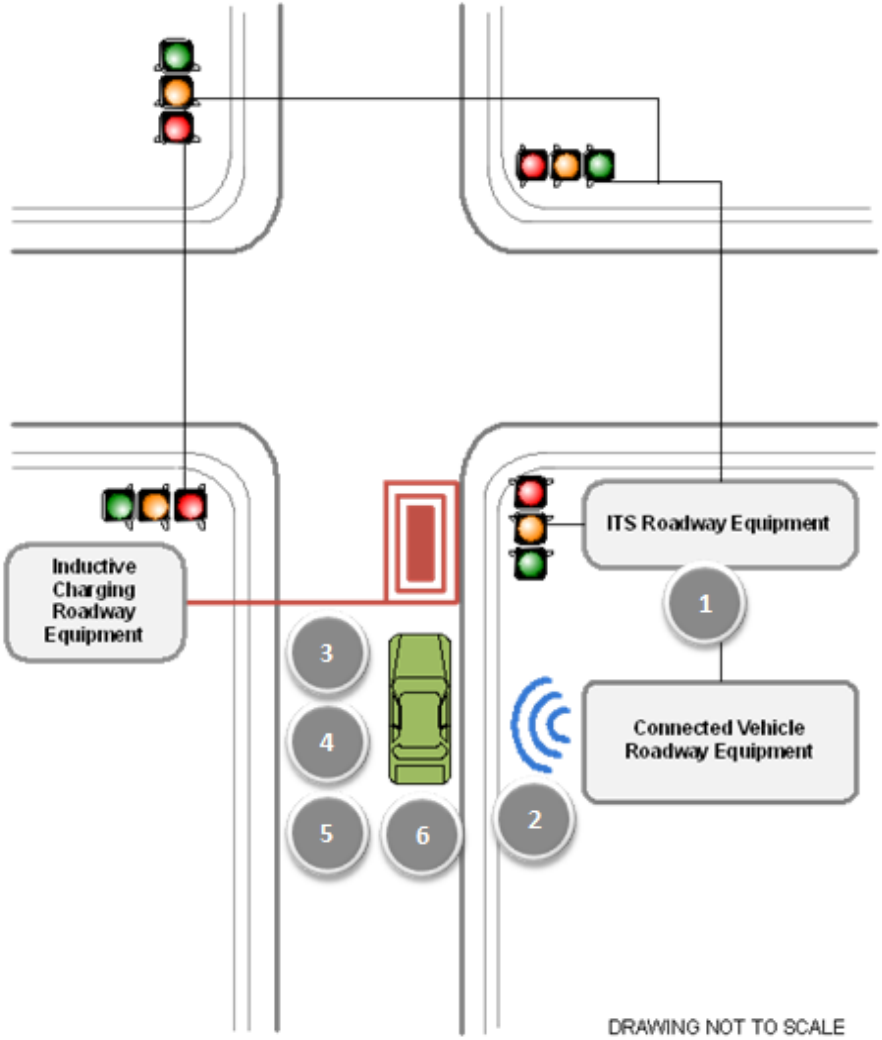
Step	Description
1	**The traffic signal controller sends the traffic signal's current SPaT data to the Connected Vehicle Roadway Equipment.** Which converts the data to a SAE J2735 SPaT message.
2	**The Eco-Traffic Signal System sends traffic conditions data to the Connected Vehicle Roadway Equipment**, including average speeds, queues at the stop bar, and incidents along the roadway**. The Eco-Traffic Signal System also sends GIDs to the Connected Vehicle Roadway Equipment describing the static physical geometry of one or more intersections.**
3	**The Connected Vehicle Roadway Equipment broadcasts SPaT, GID, and traffic condition messages.** SPaT messages are broadcasted 10 times per second.
4	**Other Vehicles broadcast vehicle status messages including the vehicle's location, motion (e.g., heading and acceleration), braking status, size, and vehicle type.**
5	**The In-Vehicle System collects data and determines the vehicle's optimal trajectory** (e.g., speed, acceleration, and braking) as the vehicle approaches or departs from the signalized intersection. • **The application first attempts to identify a speed for the vehicle to traverse the intersection during a green light.** • If the application determines that the vehicle cannot traverse the intersection on a green light, **it determines a strategy for the vehicle to decelerate to the intersection in the most environmentally efficient manner**. • **If the vehicle is stopped or slows down, the application will recommend the most environmentally efficient acceleration** as the vehicle departs from the intersection. • Finally if stopped, **the application automatically shuts down and restarts the vehicle's engine** reducing the amount of time the engine spends idling, thereby reducing fuel consumption and emissions.

Eco-Approach and Departure at Signalized Intersections



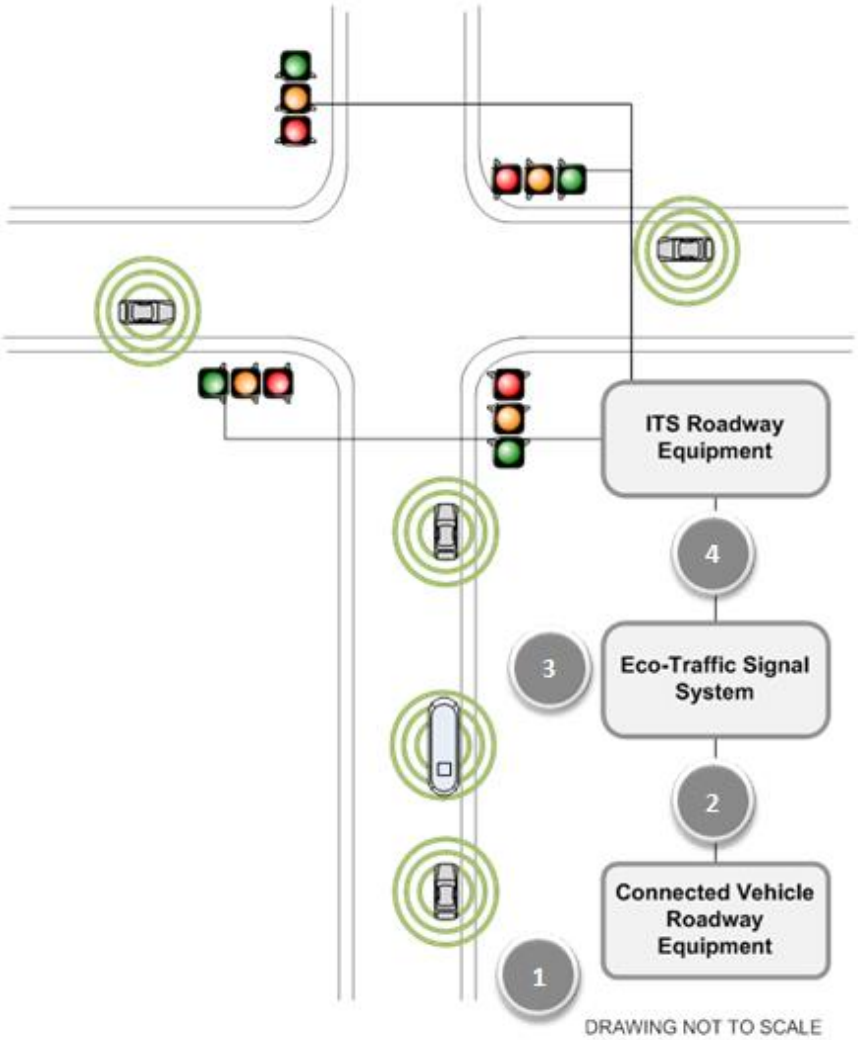
Step	Description
1	A vehicle is equipped with **an eco-driving application which also includes a feature allowing for automated control of the vehicle (e.g., the feature controls the speed and acceleration of the vehicle, but still requires the driver to steer the vehicle). The driver turns on the application and the automated driving capability using a human machine interface (HMI) in the vehicle.**
2	The traffic signal controller sends the traffic signal's current SPaT data to the Connected Vehicle Roadway Equipment. The data is converted into a SAE J2735 SPaT message.
3	The Eco-Traffic Signal System sends traffic conditions and GIDs to the Connected Vehicle Roadway Equipment describing the static physical geometry of one or more intersections.
4	The Connected Vehicle Roadway Equipment broadcasts SPaT, GID, and traffic condition messages. SPaT messages are broadcasted 10 times per second.
5	Other Vehicles broadcast vehicle status messages including the vehicle's location, motion (e.g., heading and acceleration), braking status, size, and vehicle type.
6	The In-Vehicle System collects data and determines the vehicle's optimal trajectory (e.g., speed, acceleration, and braking) as the vehicle approaches or departs from the signalized intersection.
7	**Once eco-driving recommendations are determined by the application, data is sent to vehicle actuators which adjust the speed, accelerations/decelerations, and braking of the vehicle. The driver maintains control of the steering of the vehicle. Data collected from other vehicles using vehicle-to-vehicle (V2V) communications are considered to ensure that the vehicle does not collide with other vehicles.**

Wireless Inductive Charging at Signalized Intersections



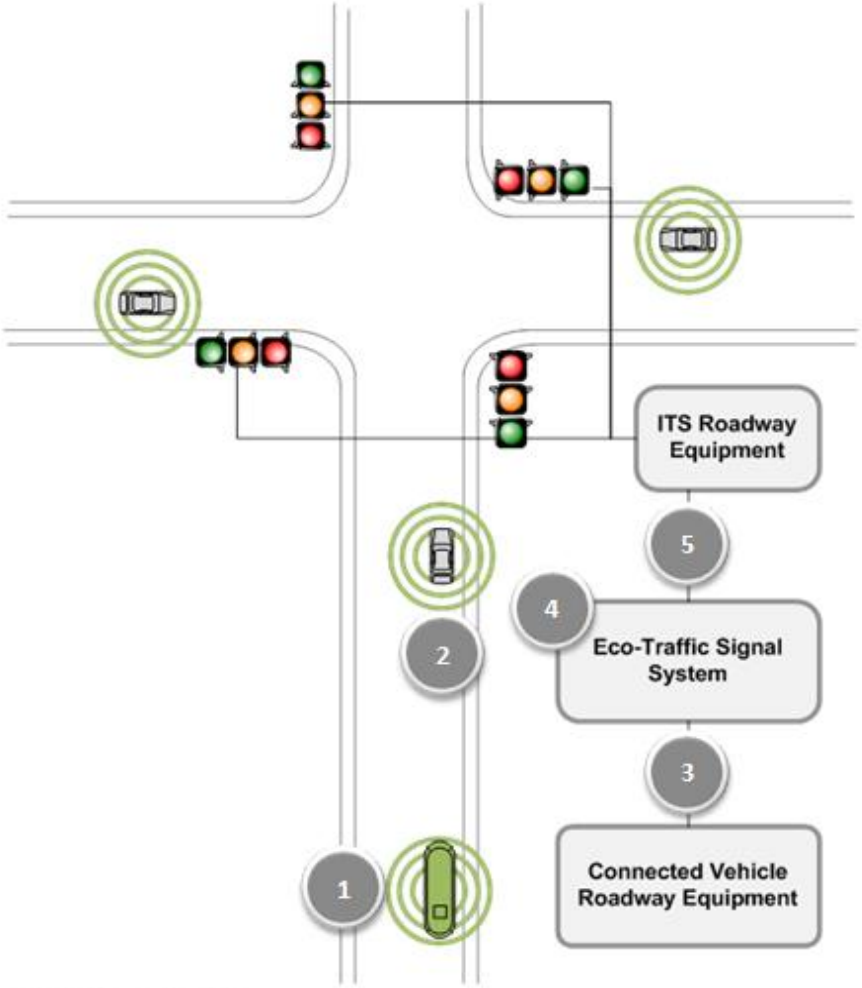
Step	Description
1	**The traffic signal controller sends the traffic signal's current SPaT data to the Connected Vehicle Roadway Equipment.** The data is converted into a SAE J2735 SPaT message.
2	The Connected Vehicle Roadway Equipment broadcasts SPaT and GID messages. **The GID message includes the locations of inductive charging infrastructure near signalized intersections.**
3	The In-Vehicle System receives SPaT and GID messages – including the location of inductive charging infrastructure. **The driver of the electric vehicle opts into an inductive charging application. The application informs the driver of the location of inductive charging infrastructure.**
4	**As the vehicle approaches the inductive charging pad at a red light, the vehicle establishes a wireless connection with the inductive charging infrastructure. A handshake process begins, payment information sent to inductive charging equipment, and electric charge is transferred from the pad to the vehicle.**
5	**The In-Vehicle System continues to receive SPaT messages as it sits at the red light. Five seconds before the traffic signal turns green, the charge terminates.**
6	**The traffic signal turns green and the vehicle accelerates away from the intersection. The In-Vehicle System notifies the driver about the vehicle's charge level.**

Eco-Traffic Signal Timing



Step	Description
1	**Vehicles send vehicle status data to the Connected Vehicle Roadway Equipment.** Vehicle status data includes data about the vehicle's location, motion (e.g., heading and acceleration), braking status, size, and vehicle type **as well as environmental status data such as the vehicle's fuel type, engine type, current emissions, average emissions, current fuel consumption, and average fuel consumption.**
2	The Connected Vehicle Roadway Equipment sends the vehicle status data to the Eco-Traffic Signal System.
3	**The Eco-Traffic Signal System processes the vehicle status data to develop real-time and predicted traffic and environmental conditions for the roadway segment. Together the traffic and environmental data are used to generate eco-traffic signal timing plans (e.g., cycle lengths, phases, offsets and other parameters).** This may include fixed timing plans based on the time of day or capabilities similar to current adaptive traffic control systems; however, **the objective should be to generate signal timing plans to minimize the environmental impact of traffic at a single intersection, along a corridor, or a region, and to select the appropriate traffic signal timing strategy to be implemented.**
4	**The Eco-Traffic Signal System sends the traffic signal timing plans to the ITS Roadway Equipment** (i.e., traffic signal controller) which implements the signal timing plan.

Eco-Traffic Signal Priority



DRAWING NOT TO SCALE

Step	Description
1	**The Transit Vehicle sends a request for signal priority to the Connected Vehicle Roadway Equipment.** In addition to the signal priority request, the transit vehicle also collects and transmits data from on-board systems including **the number of passengers on the transit vehicle and the transit vehicle's adherence to its schedule.**
2	**Vehicles in the vicinity of the signalized intersection send vehicle status data to the Connected Vehicle Roadway Equipment.** Vehicle status data includes the vehicle's location, motion (e.g., heading and acceleration), braking status, size, and vehicle type as well as the vehicle's fuel type, engine type, current emissions, average emissions, current fuel consumption, and average fuel consumption.
3	**The Connected Vehicle Roadway Equipment sends the vehicle status data to the Eco-Traffic Signal System. The Connected Vehicle Roadway Equipment also sends the Transit Vehicle's signal priority request.**
4	Upon receiving the signal priority request from the Transit Vehicle, the Eco-Traffic Signal System uses the traffic and environmental conditions data to determine if signal priority should be granted. **The Eco-Traffic Signal Priority application considers the current state of the traffic signal, traffic volumes for all approaches to the traffic signal, vehicle emissions from vehicles at all approaches to the traffic signal, traffic conditions downstream of the intersection, the number of passengers on the transit vehicle, and the transit vehicle's adherence to its schedule**.
5	**If it is determined that signal priority should be granted, the Eco-Traffic Signal System sends the request for signal priority to the ITS Roadway Equipment** which implements the traffic signal control strategy (i.e., signal priority).

Policy Considerations

- Would certain vehicle types be allowed to move through a signalized intersection at a higher priority than other vehicle types?
- Are there mobility tradeoffs? If so, how do operating entities make a decision to optimize for the environment instead of optimizing for mobility?
- How can this Operational Scenario facilitate “green” choices by:
  - Drivers,
  - State and local DOT’s operating the transportation system, and
  - Decision Makers?
- How can this Operational Scenario incentivize “green” choices by:
  - Drivers,
  - State and local DOT’s operating the transportation system, and
  - Decision Makers?
- How does open data sharing and standardization be used to support public and private sector deployment?
- Under what situation(s) would an operating entity choose to optimize traffic signals for the environment?
- How do Decision Makers value Eco-Signal Operations applications as an option for investing scarce resources?

Educational Considerations

- What are the social benefits of “green” transportation decisions?
  - Drivers
  - State and local DOT’s operating the transportation system
- What types of educational campaigns could be used to educate the traveling public to make green transportation choices?
- What types of educational campaigns could be used to educate entities operating traffic signal systems to optimize for the environment?
- How do you incentivize a choice versus another choice? And how do you get people to act on that choice?

Provide travelers and entities operating the transportation network the information they need to make “green” transportation choices

Sources

1. U.S. Department of Transportation: Research and Innovative Technology Administration. (2013, September). *AERIS Memorandum of Preliminary Modeling Results of the Eco-Approach and Departure at Signalized Intersection Application.*